TECHNICAL REPORT
NATICK/TR-13/030

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EFFECTS OF FOUR SOLE CONSTRUCTIONS FOR COMBAT BOOTS ON LOWER EXTREMITY INJURIES AMONG MEN AND WOMEN IN U.S. ARMY BASIC COMBAT TRAINING

by
Carolyn K. Bensel

September 2013

Final Report
September 2009 – May 2010

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U.S. Army Natick Soldier Research, Development and Engineering Center
Natick, Massachusetts 01760-5020

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
30-09-2013

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
September 2009-May 2010

4. TITLE AND SUBTITLE
EFFECTS OF FOUR SOLE CONSTRUCTIONS FOR COMBAT BOOTS ON LOWER EXTREMITY INJURIES AMONG MEN AND WOMEN IN U.S. ARMY BASIC COMBAT TRAINING

5a. CONTRACT NUMBER
MIPR 8HDATS1274

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Carolyn K. Bensel

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Natick Soldier Research, Development and Engineering Center
ATTN: RDNS-WSH-B
Kansas St., Natick, MA 01760-5020

8. PERFORMING ORGANIZATION REPORT NUMBER
NATICK/TR-13/030

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Product Manager-Soldier Clothing and Individual Equipment (PM-SCIE)
Program Executive Office-Soldier (PEO-Soldier)
Fort Belvoir, VA 22060

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report documents a prospective study of effects of four sole constructions for combat boots on the incidence of lower extremity overuse injuries among men and women undergoing U.S. Army basic combat training. Trainees were issued boots that had identical uppers, but differed in soling system constructions. The constructions tested were direct-molded (DMS), welt (WLT), injection-molded, direct-attach with a solid rubber outsole (A-R), and injection-molded, direct-attach with a polyurethane outsole (A-P). The study sample, 1,028 men and 388 women, was randomly divided into four sole construction groups. Group assignment determined the type of boots issued for wear during 10 weeks of basic training. The principal source of data was sick call visits made for problems experienced at or below the knee. Analyses of the men's data revealed that the percentage attending at least one sick call was unaffected by the type of sole construction worn; the proportion of women attending at least one sick call for a problem at or below the knee was highest in the A-P group and lowest in the A-R group. Analyses of medical diagnoses of overuse injuries of the lower extremities did not reveal differences among sole construction groups for the men's data, but the women's data indicated that the proportion of overuse injuries was highest in the A-P group. Based upon overall study results, the A-P construction should not be considered further as a soling system for Army boots, but the A-R construction is acceptable.

15. SUBJECT TERMS

BONES	TRAUMA	FOOTWEAR	INJURY RATES	BONE FRACTURES
BOOTS	WALKING	EXTREMITIES	SOLES(FOOTWEAR)	WOUNDS AND INJURIES
FEET	STRESSES	COMBAT BOOTS	OVERUSE INJURIES	LOWER EXTREMITY INJURIES
LEGS	SURVEYS	BIOMECHANICS	ARMY PERSONNEL	MUSCULOSKELETAL INJURIES

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Carolyn K. Bensel
U	U	U	SAR	100	19b. TELEPHONE NUMBER *(include area code)* 508-233-4780

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PREFACE

The study reported here was carried out during the period from September 2009 to May 2010 by personnel of the Human Systems Integration and Sciences Division, Natick Soldier Research, Development and Engineering Center, U.S. Army Soldier Systems Center, Natick, MA. The purpose of the study was to determine the differential effects of four sole constructions for combat boots on the incidence of lower extremity injuries among U.S. Army trainees over the course of basic combat training.

The effort was funded by the Product Manager-Soldier Clothing and Individual Equipment (PM-SCIE), Program Executive Office-Soldier (PEO-Soldier), under a project entitled "Army Combat Boot Injury Reduction" (MIPR #8HDATS1274). Mr. Michael Holthe, PM-SCIE, PEO-Soldier, served as the Project Officer.

ACKNOWLEDGEMENTS

The author appreciates the full support received from the U.S. Army Training Center, Fort Jackson, and acknowledges the participation of LTC Collin Fortier, LTC Daniel Beatty, LTC Michael Bineham, MAJ Kevin Wimberly, CPT Kemau Whittington, CPT Daniel Summers, 2LT David Rice, CSM Christopher Culbertson, CSM Charlie Lakin, Jr., CSM Roderick Brown, SFC Guillermo Gonzalez, and SFC Mae Dyous. The author also wishes to thank LTC Mark Reed, M.D., LTC Shawn Scott, PT, and Ms. Colleen Barkley, PT, of the Medical Detachment, Fort Jackson; LTC Sonya Cable, Experimentation and Analysis Element, Fort Jackson; and Ms. Andrea Carlow, ATC, and Mr. Patrick Anson, ATC, Battalion Athletic Trainers, Fort Jackson.

Within the Natick Soldier Research, Development and Engineering Center (NSRDEC), the author gratefully acknowledges the support received from Ms. Megan Coyne, Ms. Sharon Schuberth, Mr. Albert Adams, III, Mr. David Brantley, Mr. Adam DiChiara, Ms. K. Blake Mitchell, Mr. Larry Lesher, Mr. Anthony Rogers, Mr. Charles Greene, and Mr. Peter Kevin Niemeyer. The author also gratefully acknowledges the guidance received from Mr. Michael Holthe, Product Manager-Soldier Clothing and Individual Equipment, Program Executive Office-Soldier. The author thanks, as well, Ms. Meghan O'Donovan and Mr. Robert Hall, NSRDEC, for their helpful comments on an earlier draft of this report.

Successful execution of the study would not have been possible without the full cooperation of Mr. David Monkowski, Director of Logistics, Fort Jackson, and Ms. Essie Smith, Chief, Clothing Initial Issue Point, Fort Jackson. Special recognition is due the active participation of our colleagues at the Clothing Initial Issue Point, who were invaluable in execution of this study: Ms. Shine, Ms. Robinson, Ms. Hammonds, Mr. Smiley, Mr. Jackson, and Mr. Moody.

EXECUTIVE SUMMARY

Between September 2009 and May 2010, the Human Systems Integration and Sciences Division, Natick Soldier Research, Development and Engineering Center (NSRDEC), conducted a field study of four sole constructions for combat boots at the request of Product Manager-Soldier Clothing and Individual Equipment (PM-SCIE), Program Executive Office-Soldier (PEO-Soldier). The findings from this study provided PM-SCIE, PEO-Soldier, with information regarding sole constructions to be included in the specifications for Army combat boots.

Background and Purpose. A prospective study of the occurrence of lower extremity problems among men and women undergoing U.S. Army basic combat training was carried out using combat boots made in four different sole constructions. The PM-SCIE, PEO-Soldier, provided the boots for the test. The uppers were the same on all boots and were the uppers used in the current Army hot weather boots. The four soling systems were: direct-molded construction (DMS); welt construction (WLT); injection-molded, direct-attach construction with a solid rubber outsole (A-R); and injection-molded, direct-attach construction with a polyurethane outsole (A-P). One thousand pairs of each of the four versions of combat boots were fabricated for this study. Each version was available in whole and half sizes ranging from 4 through 13 in the widths of regular, wide, and extra-wide. The purpose of the study was to determine the differential effects of the four sole constructions on the incidence of lower extremity injuries among Army trainees over the course of the basic training cycle. As an adjunct to the testing of the boots on trainees, boots in the four sole constructions were subjected to mechanical tests of impact properties, forefoot flexibility, and midfoot torsion by Professor Joseph Hamill, Department of Kinesiology, University of Massachusetts, Amherst.

Method. Test participants were men and women undergoing basic combat training at the U.S. Army Training Center, Fort Jackson, SC. Authorization to recruit individuals for the testing was granted by the NSRDEC Human Subject Research Determination Panel, the U.S. Army Accessions Command Human Protections Administrator, and the U.S. Army Human Protections Office. While at the Reception Station prior to the start of their basic training, men and women were briefed on the study and asked to volunteer for participation. Those individuals who volunteered were randomly divided into four sole construction groups, corresponding to the versions of sole construction being tested. The volunteers received their initial issue of military clothing in the normal manner. At the boot issue station, the volunteers were fitted by personnel of Fort Jackson who regularly issued boots to incoming trainees. The type of boots a volunteer received was determined by sole construction group assignment. A volunteer was issued two pairs of boots, identical in size and in sole construction type, for wear during basic training.

Among individuals who volunteered for the study, participation was contingent upon being fitted successfully in the test boots and beginning basic combat training upon completion of in-processing at the Reception Station. The study sample comprised 1,028 men and 388 women who met these criteria. Approximately 25% of these men and 25% of these women formed each of the four sole construction groups. The participants were distributed among 12 basic training companies, six companies in each of two battalions. The type of test boot issued to a participant did not influence battalion or company assignment, nor did it influence the platoon to which a participant was assigned. Thus, all four versions of test boots could be

represented among the individuals within one platoon. The training of participants followed normal procedures at Fort Jackson. Throughout the basic training cycle, participants wore the test boots issued to them whenever combat boots were the specified footwear for a given activity.

The principal sources of study data were records of the sick call visits for lower extremity complaints made by test participants over the approximately 10 weeks of their basic training. The date of each sick call, the trainee's complaint, the diagnosis, and the disposition of the case (i.e., return to full duty, duty restriction, hospitalization) were recorded. If attending medical personnel issued a duty restriction, the nature of the restriction and its duration were entered as data. The durations of hospitalizations were also entered. The sick calls recorded were those for problems occurring at and below the knee. Other sources of data acquired in the study were responses on two survey questionnaires administered to test participants. One questionnaire was given at the time of boot issue to obtain demographic information on the participants (e.g., age, height, weight, and physical activity and injury histories). A second questionnaire was given several days before graduation to ascertain participants' experiences with their combat boots over the basic training cycle.

Results. Statistical analyses were carried out on the demographics of the trainees to assess the comparability of the sole construction groups at the start of training with regard to age, height, weight, engagement in physical activities prior to reporting for basic training, and history of past musculoskeletal injury. Analyses of the women's data did not reveal significant differences ($p > .05$) among sole construction groups with regard to demographic characteristics. The men's data yielded one small, but statistically significant ($p < .001$), difference. This was on the body mass index (BMI) measure, where the sole construction group with the highest BMI, the WLT group, differed from the group with the lowest BMI, the A-R group. The sole construction groups were also compared for the number of trainees who failed to complete basic training in the battalion to which they were originally assigned (Nongraduates). Twenty-seven men (3% of the men in the study) and 33 women (8% of the women in the study) did not finish basic training with their original battalions. Statistical analyses carried out to contrast the sole construction groups with regard to the number of Nongraduates did not reveal significant differences among the groups for either the men's or the women's data ($p >.05$).

A number of statistical analyses were performed on the data related to sick calls made by test participants. Over all sole construction groups, approximately 17% of the male participants and 41% of the females attended sick call at least once during basic training for a complaint related to the knee, shank, ankle, or foot. For the men, the percentage attending at least one sick call was unaffected by the type of sole construction being worn. For the women, the proportion attending sick call at least once for a complaint at or below the knee was highest in the A-P group, followed by the DMS group, and lowest in the A-R group. The A-P and the DMS groups did not differ significantly from each other ($p > .05$), but both groups had significantly larger proportions of women attending at least one sick call than the A-R group ($p < .001$). Similarly, the A-R group did not differ significantly from the WLT ($p > .05$), but both these groups had significantly smaller proportions of sick call attendees among the women than the A-P group did ($p < .001$).

A sick call visit for a lower extremity complaint could result in an individual being judged fit by the attending medical personnel to engage fully in all training activities. On the other hand, medical personnel could prescribe a day or more of recuperation (i.e., place the individual on profile), restricting the individual from engaging in some or all training activities for a period of time. Over all sole construction groups, approximately 10% of the men and 29% of the women had a least one day of restricted duty due to a problem of the knee, shank, ankle, or foot. The percentage of male participants receiving at least one restricted day was not significantly affected ($p > .05$) by sole construction group assignment. However, the women's data revealed significant differences ($p < .02$) among sole construction groups: The proportion of women who had one or more days of restricted duty was significantly higher in the A-P group than in the WLT group.

The diagnoses rendered by attendant medical personnel at each sick call visit made by a trainee for a reported problem at or below the knee were categorized on the basis of whether an overuse injury was diagnosed. Overuse injuries were defined as conditions associated with repetitive microtrauma of a muscle, tendon, ligament, bone, joint, or surrounding tissue. Analyses were performed on the men's and the women's data to determine whether there were differences among sole construction groups in the proportions of individuals diagnosed for an overuse injury at or below the knee. The men's data did not reveal significant differences ($p > .05$) among sole construction groups. For the women's data, the proportion of overuse injuries in the A-P group, the group with the highest percentage of injuries to the knee, shank, ankle, or foot, was significantly higher ($p < .01$) than the proportion in the group with the lowest percentage, the A-R group.

A survey was administered several days prior to graduation from basic training to elicit participants' opinions of their boots, and statistical analyses were carried out to compare the responses of individuals in the four sole construction groups. Neither the men's nor the women's data revealed significant differences ($p > .05$) among sole construction groups in ratings given to the overall comfort of the boots. Further, the women's data did not reveal differences among the groups in responses to any of the survey questions. The men's data did yield differences among the groups that were statistically significant. With regard to boot fit, the proportions of men in the A-R and the A-P groups responding that their boots fit properly were significantly higher ($p < .05$) than the proportions of men in the DMS and the WLT groups reporting a proper fit. In terms of ankle support, the A-R and the A-P groups had significantly higher ($p < .05$) proportions of men who indicated that the ankle support provided by the boots was adequate, compared with the proportion in the DMS group.

The mechanical tests performed on the four boot sole constructions by Professor Hamill revealed some differences among sole constructions. On the impact test, the WLT construction exhibited properties that were superior to those of the other boots in terms of having the lowest peak g values and the longest times to peak g. With regard to stiffness values on the forefoot flexibility test, lower values, which imply a lower resistance to flexion across the metatarsal heads, were obtained with the DMS and the WLT than with the A-R and the A-P constructions. For midfoot torsion, the A-P had greater resistance to rotation in pronation compared with the other three boot constructions. Resistance to rotation is considered a positive characteristic.

Conclusions. With regard to overuse injuries occurring among Army trainees who wore the different constructions, the men's data related to sick calls for complaints of problems at or below the knee did not reveal significant differences among the four types of sole constructions tested. The women's sick call-related data indicated that the WLT and the A-R constructions were more acceptable than the DMS and the A-P constructions. Based on findings from the mechanical testing he conducted, Professor Hamill concluded that, of the four sole constructions studied, the DMS exhibited the properties most desirable in a military boot. The conclusion was supported by data indicating that the DMS had the lowest stiffness values and that its midfoot torsion values were not extreme. Further, although the impact properties of the DMS were poorer than those of the other constructions, results for the DMS construction on the impact test did not differ greatly from those for the other three constructions. The men's injury data provided no strong evidence to suggest that one of the other sole constructions was preferable to the DMS. The women's injury data favored the A-R and the WLT constructions over the DMS. Hamill's testing indicated that the A-R was somewhat better than the DMS in terms of impact characteristics and that the WLT had the best shock attenuation. The A-R and the WLT also had stiffness and torsion characteristics that were not greatly different than those of the DMS. The A-P, which along with the DMS was associated with higher incidences of women's overuse injuries, exhibited greater resistance to rotation in pronation than the other sole constructions. It is not known whether this characteristic of the A-P construction contributed to the women's injuries.

Recommendations. The overall results from the study indicate that an injection-molded, direct-attach construction with a polyurethane outsole, represented by the A-P test boot, should not be considered further as a soling system for Army boots. An injection-molded, direct-attach construction with a rubber outsole, represented by the A-R test boot, is acceptable from the perspective of lower extremity health and user acceptance. The results of the study also indicate that a welt and a direct-molded sole construction are acceptable. However, there is the possibility that women would experience fewer overuse injuries by wearing boots in a welt construction, compared with a direct-molded sole construction.

The following recommendations are made based on the findings from this study:

- An injection-molded, direct-attach construction with a polyurethane outsole should not be considered further as a soling system for Army boots.
- If an injection-molded soling system is going to be authorized for production of Army boots, the A-R boot tested in the current study is a good choice from the perspective of lower extremity health and user acceptance.
- There is no basis from the present study to recommend that either of the two currently authorized soling systems tested here, the welt and the direct-molded sole, be deleted from the Army boot specification. However, there is the possibility that women would experience fewer overuse injuries by wearing boots in a welt construction rather than in a direct-molded sole construction.
- Breakage of stitching on the uppers was noted during visual inspections of the study boots after they had been worn for approximately 10 weeks. Approaches for remedying this problem should be explored.

EFFECTS OF FOUR SOLE CONSTRUCTIONS FOR COMBAT BOOTS ON LOWER EXTREMITY INJURIES AMONG MEN AND WOMEN IN U.S. ARMY BASIC COMBAT TRAINING

INTRODUCTION

This report documents a prospective study of the effects of four different sole constructions for combat boots on the occurrence of lower extremity overuse injuries among male and female U.S. Army trainees. The study was conducted by the Natick Soldier Research, Development and Engineering Center (NSRDEC) between September 2009 and May 2010. Four versions of combat boots that were identical to each other, except for the soling system, were produced for this study. The versions were issued randomly to trainees immediately prior to the start of their Army basic combat training. The trainees used the boots throughout their training whenever combat boots were the footwear to be worn during a given activity. Data were acquired on sick call visits made by the trainees for lower extremity complaints. The purpose of the study was to determine whether the incidence of overuse injuries to the lower extremities was differentially affected by the boot soling system used. A survey questionnaire was also administered at the end of training to obtain opinions of the trainees regarding their boots.

The U.S. Army combat boots currently used most frequently by Soldiers are a boot developed for hot weather wear [designated as Army Combat Boot (Hot Weather)[1]] and one developed for temperate weather [designated as Army Combat Boot (Temperate Weather)]. The uppers of both versions are made of flesh-side-out cattlehide leather and a nylon fabric. The uppers of the temperate weather boots have a waterproof, breathable laminate lining, whereas the hot weather boot uppers are unlined. Although the uppers are somewhat different, the soles of both the hot weather and the temperate weather boots have three-layers: a solid base sole, a cushioned midsole, and an outsole.

Three-layer soles were introduced into Army footwear about 10 years ago. From the 1960s until 2002, U.S. Army combat boots incorporated a solid rubber soling system construction, which entailed vulcanizing a solid rubber outsole directly to a base sole (Park & Swain, 1967). The change in the construction of the soles of Army combat boots was an outcome of an applied research program undertaken by NSRDEC. The multiphase research program, which began in 1998, was conducted to identify concepts for military combat boots that would enhance the locomotor efficiency of the wearer and reduce musculoskeletal overuse injuries of the lower extremities among Soldiers wearing the boots compared with Soldiers wearing the Army combat boots current at that time.

In recent decades, noncombat injuries have become an increasingly important contributor to compromising the health and operational readiness of the U.S. Armed Forces (Peake, 2000). A large number of noncombat injuries are musculoskeletal problems of the lower extremities. Data reported for the four U.S. military services in calendar year 2006 indicated that the rate of inpatient and outpatient visits for these problems was almost 900 per 1,000 service members per year (Jones, Canham-Chervak, Canada, Mitchener, & Moore, 2010). Overuse injuries of the

[1]Army Combat Boot (Hot Weather) Detail Specification, MIL-DTL-32237, February 6, 2007.

lower extremities occur in all segments of the military population, but individuals undergoing initial military training are the portion of the population at greatest risk, and the majority of their injuries occur at or below the knee (Kaufman, Brodine, & Shaffer, 2000; Niebuhr, Powers, Li, & Millikan, 2006). It has been reported that about 25% of the men and 50% of the women undergoing U.S. Army basic combat training incur at least one training-related injury and that about 80% of these injuries are overuse problems of the lower extremities (U.S. Department of the Army, 2011).

Sustaining an injury of any kind during initial military training has negative consequences for the individual and for the Armed Forces. Most importantly, it increases the likelihood of being discharged from service (Knapik et al., 2001). The most common causes of disability discharges among first year enlistees in the Army are musculoskeletal system problems, which account for over 80% of the discharges (Accession Medical Standards Analysis & Research Agency, 2011; Niebuhr et al., 2006). The investment lost by the military services due to separation of enlistees from the military prior to completion of basic training is substantial (General Accounting Office, 1997). For fiscal year 2007, the cost to the U.S. Army alone because of attrition from basic combat training has been put at $33 to $57 million, depending on when during training the individual was discharged (Swedler, Knapik, Williams, Grier, & Jones, 2011).

Devising interventions to reduce attrition due to lower extremity injuries requires knowledge of elements affecting morbidity to these injuries. Investigations undertaken for this purpose have identified a number of risk factors, including female gender, low aerobic fitness, low muscular endurance, cigarette smoking prior to basic training, low physical activity prior to training, low socio-economic status, and high body fat percentage (Almeida, Maxwell-Williams, Shaffer, & Brodine, 1999; Havenetidis & Paxinos, 2011; Jones, Cowan, & Knapik, 1994; Jones, Cowan, Tomlinson, Robinson, Polly, & Frykman, 1993; Lee, McCreary, & Villeneuve, 2011; Swedler et al., 2011). Boot design is also a factor that affects occurrence of lower extremity injuries (Bensel, 1976; Bensel & Kish, 1983; Knapik, Hauret, & Jones, 2006), and the research program begun at NSRDEC in 1998 was undertaken with the goal of improving combat boots by identifying boot concepts that would reduce the incidence of overuse injuries of the lower extremities compared with the then-current Army combat boots.

The approach taken in executing the research program consisted of designing and fabricating prototype combat boots to meet certain mechanical performance criteria and testing the prototypes against the criteria. The performance criteria were quantitative measures of physical properties of footwear that could be assessed using objective mechanical testing techniques (Bensel, 2000; Hamill & Bensel, 1992). The properties included impact characteristics (e.g., peak g, time to peak g), forefoot stiffness, and rearfoot stability. The postulation underlying this approach to boot design was that footwear properties such as these affect the risk of musculoskeletal injury to the lower extremities. Thus, the research program objective of reducing lower extremity overuse injuries was addressed by fabricating prototype boots to embody quantifiably improved levels of mechanical properties, relative to the levels in the then-current U.S. Army combat boots.

In addition to mechanical properties, the prototypes were designed to meet chemical and physical requirements related to durability (e.g., sole abrasion resistance, sole-to-upper bond strength). With regard to appearance and functionality, the combat boots in widest use in the U.S. Army at the time the research program was underway served as the model for the prototypes. These Army boots had an upper that was different from the uppers in the current combat boots. The upper of the earlier boots was fabricated entirely of grain-side-out cattlehide leather; no fabric was used.

As part of the research program, a number of footwear companies worked with NSRDEC to design boots against the biomechanical, chemical, and physical criteria. This effort yielded five prototype versions that were produced in small quantities and underwent limited testing on Soldiers in the laboratory and in the field. Based on findings from the small-scale testing, two versions were dropped from further consideration, and modifications were made to the other three. The three versions were then produced in quantity and used in a large-scale, prospective study of the incidence of lower extremity disorders among men and women undergoing U.S. Army basic combat training. The study began in 1999 and was completed in 2000.

The three prototype versions had identical uppers, which were similar to the grain-side-out, all-leather uppers in the then-current Army combat boots. All prototypes were made over the same last system, the MIL-5, which was the last system used at the time to produce the Army boots (Freedman et al., 1946; Mann & Zacharias, 1952; Perkins, 1961; Potter, 1961, 1962; United Shoe Machinery Corporation, 1955). Unlike the solid rubber soling system of the then-current Army boots, each prototype had a three-layer sole, comprised of a solid base sole, a cushioned midsole, and an outsole. The prototype versions differed from each other in the fabrication techniques used to construct the soling systems. They were a three-layer direct-molded, an injection-molded direct attach, and a cement construction.

The study conducted on Army trainees addressed the efficacy of the prototype boot versions in reducing stress-related lower extremity injuries relative to the injuries incurred with the then-current Army combat boots. In the study, either a prototype boot version or the Army boots were issued randomly to 799 men and 707 women immediately prior to the start of their basic training at the U.S. Army Training Center, Fort Jackson, SC. To acquire the study data, sick call visits made for lower extremity complaints were tracked throughout the participants' training. The date, diagnosis, and disposition of each sick call visit for these problems were recorded. The data were then analyzed to determine the incidence of overuse injuries of the lower extremities as a function of the boot type worn (Bensel, 2000).

Study results revealed that the incidence of overuse injuries was higher among the trainees wearing the Army boots than among the trainees wearing a prototype version (Bensel, 2000). Statistical analyses were performed to compare the Army boots with each of the prototype versions for risk of overuse injuries to the knee, shank, ankle, or foot. It was found that relative risk of injury was 10 to 30% higher for trainees in the Army boots than for trainees wearing a prototype version.

Based on the findings from the study, the Product Manager-Soldier Clothing and Individual Equipment (PM-SCIE) of the Program Executive Office-Soldier (PEO-Soldier), the

Army life-cycle manager responsible for development and fielding of Army footwear, rewrote specifications for combat boots in 2002 to require three-layer soles. To broaden the supply base and ensure a sufficient, continuous supply of combat boots, the PM-SCIE authorized multiple three-layer sole constructions. These were direct-molded, welt, and stitch-down constructions. Boots in all three constructions have been procured by the Army over the intervening years, with the direct-molded construction comprising a larger quantity of the boots produced for the Army than either of the other two constructions.

In addition to introducing a different soling system, the PM-SCIE introduced other changes to combat boots in the 2002 time frame. The major ones were the replacement of the all-leather upper with a leather and fabric upper, the introduction of a waterproof, breathable lining in temperate weather boots, and the replacement of the MIL-5 system of lasts. The Army had long required that its combat boots be made over the MIL-5. The new policy permitted each company manufacturing Army boots to use a last system of its choosing, with the constraint that the boots produced provide an acceptable fit for the Army user population.

Since the introduction of three-layer soling systems, some footwear companies have changed from one sole manufacturing method to another; other companies have expanded to add the capability to use two different methods. The result of the changes in the industry is that sole constructions authorized for combat boots could be limited to one or two methods without negatively affecting the supply of Army combat boots. As part of the consideration of changes that might, therefore, be made in combat boot specifications, the PM-SCIE requested that NSRDEC conduct another prospective study of the incidence of lower extremity problems among Army trainees, this time using boots made in four sole constructions. The study, which is reported here, was undertaken by NSRDEC to determine whether the incidence of overuse injuries to the lower extremities would be differentially affected by the four soling systems.

The PM-SCIE, PEO-Soldier, provided test boots for the study, which were hot weather combat boots fabricated in the four different constructions. The soling systems included direct-molded and welt constructions, constructions authorized for combat boot production. The other systems were two versions of an injection-molded, direct-attach construction, one with a solid rubber outsole and one with a polyurethane outsole. The direct-attach construction method was not authorized under the specification. It was one of the constructions tested in NSRDEC's earlier research program. Like the other three-layer soling systems included in that research, relative risk of overuse injuries was found to be lower with that construction than with the two-layer construction in the then-current Army combat boots (Bensel, 2000).

In addition to the testing on Army trainees, the mechanical properties of the boots in the different soling constructions were assessed using methods similar to those used during the NSRDEC research program that resulted in the Army's adoption of the three-layer construction. The mechanical testing was carried out under a contract with NSRDEC by Professor Joseph Hamill, Department of Kinesiology, University of Massachusetts-Amherst. Professor Hamill's report is in Appendix A.

METHOD

Footwear Tested

The footwear items in this study were four versions of combat boots that were identical to each other, except for the soling system. The upper of all test boots (Figure 1) was the one used in the current Army hot weather boots. The hot weather boot upper is made of flesh-side-out cattlehide leather and a nylon fabric, with a backstay and ankle reinforcement tape made of nylon webbing. The closure system is a combination of closed loops and eyelets. A means for water drainage from the boot interior is provided by two eyelets located in the arch area of each upper. The heel counter and the box toe are made of thermoplastic, the shank is fiberglass, and the insole is fiberboard. There is a padded collar at the top of the boots, filled with latex foam. The height of the boot upper varies somewhat with boot size. In a size 10 regular, the height is approximately 25.4 cm (10 in.), as measured from the front edge of the heel, where the heel attaches to the outsole behind the instep, to the top of the boot. A removable insert is placed in the Army hot weather boots at the factory. The same insert was provided in all the test boots. The insert is contoured and extends from heel to toe. The insert is a polyether polyurethane material molded directly to a fabric top cover.

Figure 1. Exemplar boot showing the upper used on all four versions of the footwear tested in the study.

One thousand pairs of each of the four test versions of combat boots were fabricated for this study. Ten pairs of each version were held aside as samples and for use in the mechanical testing; 990 pairs of each version were released for use in this study. Each version was available in whole and half sizes, ranging from 4 through 13. The widths in sizes from 4 through 11½ were regular, wide, and extra-wide (R, W, and XW, respectively). Sizes 12 through 13 were available in two widths, R and W. The tariffs of sizes for the study boots are in Appendix B.

The PM-SCIE, PEO-Soldier, procured the footwear for testing through contracts with two manufacturers that produce Army combat boots on a regular basis, the Belleville Shoe Manufacturing Company (Belleville, IL, USA) and McRae Industries, Incorporated (Mount Gilead, NC, USA). Each company provided two of the four versions of the test boots. The two versions manufactured by a company were made over one last system, the system that the company normally uses in production of Army combat boots. However, the last system used by Belleville differs from that used by McRae. According to the PM-SCIE, the basic length and girth measurements of the two systems are highly similar on a size-by-size basis (M. Holthe, personal communication, July 14, 2009).

The soling systems in the four versions of the test boots are described below. Photographs of portions of each type of test boot are presented in Figures 2 through 4.

Three-Layer Direct-Molded Sole (DMS)

McRae Industries manufactured the boots in the DMS construction. The boot was flat-lasted with a solid rubber base sole that was directly vulcanized to the boot upper. A cushioned midsole was cemented to the base sole and to a solid rubber tread outsole. The cushioned midsole was polyether polyurethane with a density of 0.40 to 0.60 $g \cdot cm^{-3}$. The outsole design was the Vibram® Sierra (Style 1276; Quabaug Corporation, North Brookfield, MA, USA). A pair of these boots in a size 9R weighed 1.63 kg (3.60 lb).

Three-Layer Welt Sole (WLT)

Boots in the WLT construction were manufactured by McRae Industries. The solid rubber base sole of this boot version was stitched to the boot upper. A cushioned midsole of polyether polyurethane with a density of 0.40 to 0.60 $g \cdot cm^{-3}$ was cemented to the base sole and to the solid rubber tread outsole. The outsole design was the Vibram Sierra (Style 1276; Quabaug Corporation). A pair of these boots in a size 9R weighed 1.70 kg (3.74 lb).

Direct Attach With Rubber Outsole (A-R)

The boots incorporating A-R soling construction were produced by the Belleville Shoe Manufacturing Company. This boot version was flat-lasted with an injection-molded midsole. The midsole, which was made of polyether polyurethane with a density of 0.40 to 0.60 $g \cdot cm^{-3}$, was directly attached to the boot upper and to a pre-molded, solid rubber tread outsole. The midsole was formed by injecting the polyurethane directly between the rubber outsole and the boot upper. The outsole was the Vibram Sierra (Style 1276; Quabaug Corporation). A pair of these boots in a size 9R weighed 1.56 kg (3.45 lb).

Direct Attach With Polyurethane Outsole (A-P)

The A-P boots, produced by the Belleville Shoe Manufacturing Company, incorporated the same sole construction and materials as the A-R version, with the exception of the outsole. The outsole was polyether polyurethane, rather than rubber. The boots were flat-lasted, and the midsole was polyether polyurethane with a density of 0.40 to 0.60 $g \cdot cm^{-3}$. The midsole was formed by injecting the polyurethane directly between the outsole and the boot upper. The polyurethane outsole, which had a density of 1.20 $g \cdot cm^{-3}$, was the MeraMAX® 338-1 pattern (Meramec Group, Incorporated, Sullivan, MO, USA). A pair of these boots in a size 9R weighed 1.55 kg (3.42 lb).

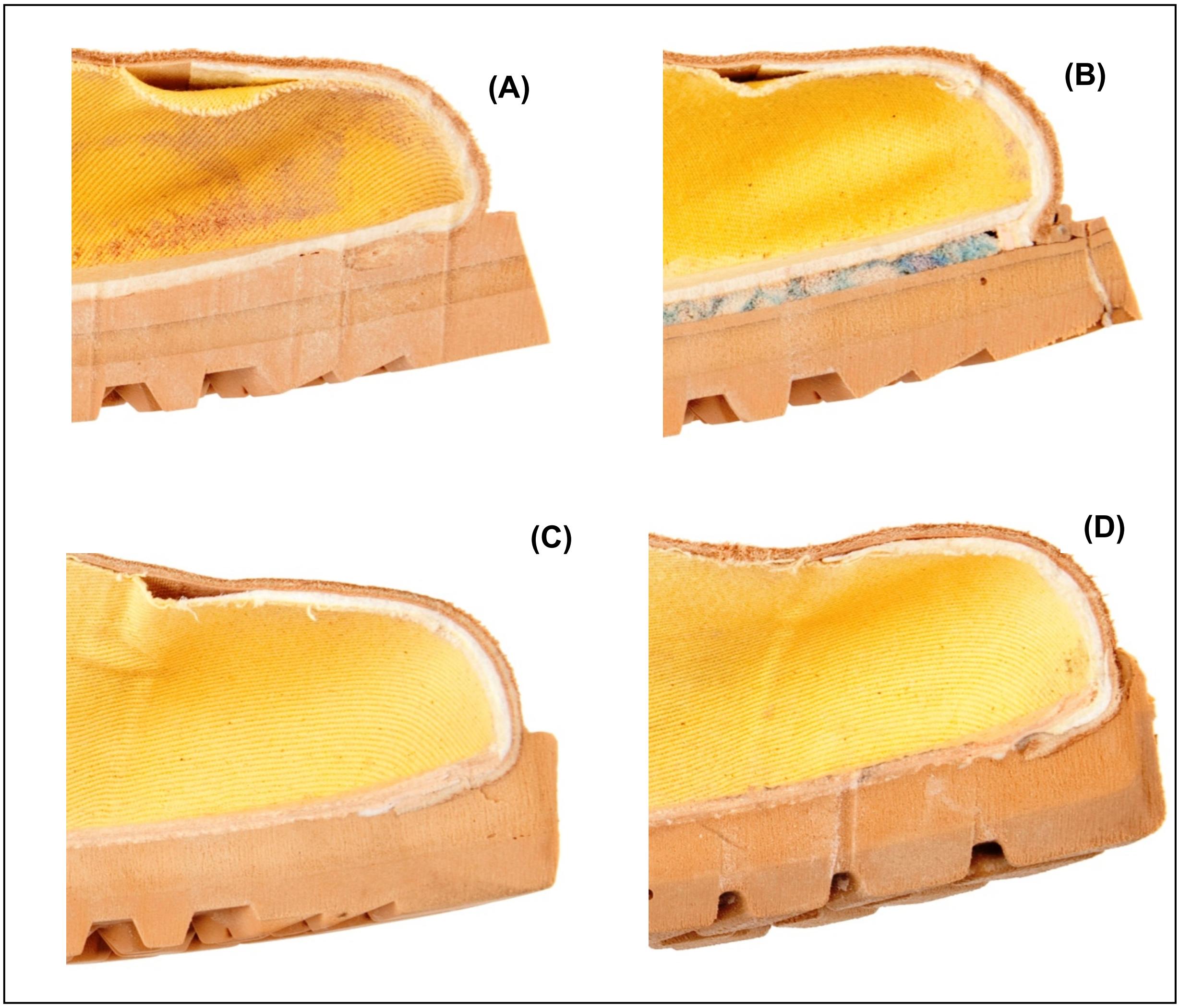

Figure 2. Cross-sectional views of the toe areas of the four types of test boots: (A) DMS, (B) WLT, (C) A-R, (D) A-P.

Figure 3. Views of the four types of test boots, showing the intact soles: (A) DMS, (B) WLT, (C) A-R, (D) A-P.

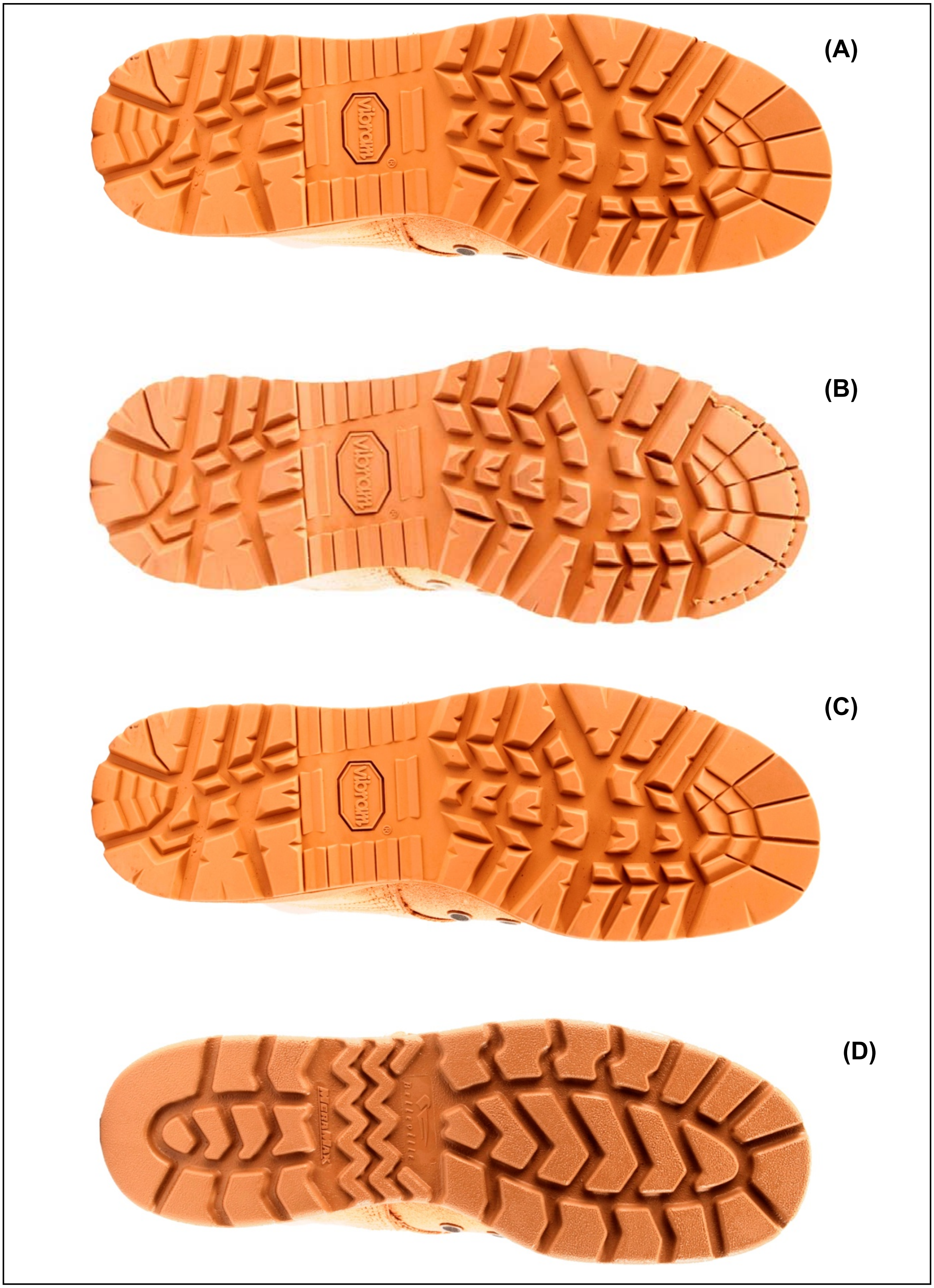

Figure 4. Views of the bottoms of the outsoles of the four types of test boots: (A) DMS, (B) WLT, (C) A-R, (D) A-P.

Participants

Test participants were 1,028 men and 388 women undergoing basic combat training at the U.S. Army Training Center, Fort Jackson, SC. Authorization to recruit individuals for the testing was granted after review of the study protocol by the NSRDEC Human Subject Research Determination Panel, the U.S. Army Accessions Command Human Protections Administrator, and the U.S. Army Human Research Protections Office.

Prior to the formal start of basic training, trainees are assigned to Fort Jackson's Reception Station, where they engage in initial orientation and administrative activities. One activity, which requires several hours, entails reporting to the Clothing Initial Issue Point (CIIP) in order to receive Army clothing, including boots. Participants were recruited for the study from among the male and the female trainees who reported to the CIIP between September 28, 2009, and October 29, 2009. The date of initiation of participant recruitment into the study coincided with the day that trainees forming a basic training battalion began processing through the CIIP. Participant recruitment continued for 20 days, through the end of processing of trainees forming a second training battalion.

The men and women arriving at the CIIP during the time period of recruitment into the study were asked to volunteer for the testing after being informed of the purpose of the study, the nature of the test conditions, and a volunteer's right to discontinue participation at any time without penalty. Those who agreed to participate expressed their understanding by signing a volunteer consent form. They then received and completed a questionnaire and other study forms before proceeding through the clothing issue process. The men and women who chose not to volunteer for the study proceeded immediately with clothing issue activities and had no future involvement with testing.

Among the individuals who volunteered, participation in the study was contingent upon being fitted successfully in test boots and beginning basic combat training upon completion of in-processing at the Reception Station. Men and women who consented to participate, but did not meet these two criteria were not enrolled as participants and had no further involvement with testing activities.

Procedure

Test Initiation

Immediately upon consenting for the study, volunteers completed a questionnaire designed to obtain information on their physical characteristics (e.g., body weight, height), demographics (e.g., race), and on other topics, such as physical activity and injury histories. A copy of the questionnaire is presented in Appendix C. At this time, each volunteer was randomly assigned to one of four sole construction groups, corresponding to boots in the four versions of sole construction being tested. The sole construction group to which a volunteer was assigned was determined by an alphanumeric code entered on a study form given to each individual. Each code was printed on 25% of the forms distributed randomly to the men and on 25% of the forms distributed randomly to the women. The volunteers then spent several hours proceeding through

various stations at the CIIP, where they received Army clothing items, with the boot issue station being the last. At the boot issue station, the volunteers, wearing standard Army socks, were fitted for the test boots determined by sole construction group assignment.

The fitting of all boots was accomplished by personnel of Fort Jackson who regularly issued boots to incoming trainees. The personnel followed their standard procedures of first measuring the feet with a Brannock Foot Measuring Device® (The Brannock Device Company, Incorporated, Liverpool, NY, USA) to obtain an initial, or predicted, size (i.e., length and width). Personnel inspected the fit of the boots in the predicted size and tried other sizes as required to obtain a proper fit. Once a proper fit was achieved, the trainee was given a second pair of test boots of the same sole construction and size as the first, and the size and version issued were recorded on the trainee's study form.

The same criteria were applied to each version of test boot in determining whether the boot fit a trainee properly. If a trainee could not be properly fitted in the type of test boot indicated on his or her study form, a different version of test boot was tried. If a proper fit could not be achieved in any of the types of test boots, the trainee was fitted for and issued standard Army boots from the regular stock at the CIIP, and that trainee was not enrolled as a study participant. The frequency with which trainees who had consented to participate in the study were issued boots from the regular stock increased over time as the supplies of test boots in the various sizes were depleted.

Army trainees are authorized to receive three pairs of combat boots as part of their initial issue of Army clothing, two pairs of hot weather and one pair of temperate weather boots. For purposes of this study, individuals who were issued test boots received only the two pairs of hot weather boots, the configuration in which all test boots were made. They were issued temperate weather boots at a later time in the training cycle, shortly before graduating from training. Thus, their Army authorized boot allotment was fulfilled.

In addition to combat boots, trainees wear running shoes during basic training. Running shoes are not Army issue items. Rather, trainees use a portion of their clothing allowance to purchase a pair at the Post Exchange (PX) during their time of in-processing at the Reception Station. The PX maintains a stock of running shoes in a variety of commercial brands and models, which are divided into motion control, stability, and cushioning types based on manufacturers' classifications. Before running shoes are purchased, Reception Station cadre visually examine the shape of the plantar surface of trainees' feet, which is assumed to indicate foot arch height, and prescribe the type of shoe each trainee is to purchase. High, normal, and low arch categories correspond to motion control, stability, and cushioning shoes, respectively (Knapik et al., 2009). Volunteers for this study obtained running shoes following this usual process.

The standard procedure at Fort Jackson is for the approximately 10 weeks of basic training to begin once in-processing at the Reception Station, lasting 3 to 5 days on average, is completed. Administrative or medical matters, such as an erroneous enlistment or a pre-existing medical condition, may prevent an individual from beginning training and instead result in a discharge from the service. An individual may also fail to pass the initial Army physical fitness

test and be assigned to undergo a remedial physical training program before beginning formal basic training. Some men and women who consented to participate in the study and received test boots did not begin basic training for such reasons and were not enrolled as study participants. The numbers of men and women who were fitted successfully in test boots, started basic training, and were, therefore, enrolled as study participants are presented in Table 1 for each boot type.

Table 1
Number and Percentage of Participants in Each Sole Construction Group

	Men		Women		Men + Women	
Sole Type	*n*	%	*n*	%	*N*	%
DMS	291	28.3	116	29.9	407	28.7
WLT	258	25.1	85	21.9	343	24.2
A-R	239	23.2	97	25.0	336	23.7
A-P	240	23.3	90	23.2	330	23.3
TOTAL	1028	100.0	388	100.0	1416	100.0

Test Execution

The study participants were distributed among 12 basic training companies, six companies in each of two battalions. The type of test boot issued to a participant did not influence battalion or company assignment, nor did it influence the platoon to which a participant was assigned. Thus, all four versions of test boots could be represented among the individuals within one platoon. Likewise, a platoon could include individuals who were participants in the study and individuals who were not.

The first battalion began formal training on October 6, 2009, and the second battalion began on October 20, 2009. In both battalions, the length of the training cycle was approximately 65 days. The training of participants followed normal procedures and, as is standard practice at Fort Jackson, men and women were assigned to the same platoons. Throughout the basic training cycle, participants wore the boots issued to them whenever combat boots were the specified footwear for a given activity.

The schedule of daily activities was similar for all basic training companies involved in this study. There was physical training (PT) 4 to 6 days per week, for 1 to 1.5 hr per day; military training filled most of the rest of the day. The PT exercises alternated between "cardiopulmonary days," with distance running and sprinting, and "muscle strength days," with emphasis on push-ups, sit-ups, and calisthenics. The PT uniform and running shoes were used for these events. Military training included drill and ceremony, road marches, weapons training, rifle marksmanship, obstacles courses, and a 5-day field operation. Generally, boots were worn during the military training activities.

When they required medical attention, study participants followed normal procedures, reporting for sick call at their battalion. Depending upon the nature and severity of the problem, the medic at battalion sick call provided treatment, sent the individual to an athletic trainer, also at the battalion level, or sent the individual to the Fort Jackson Troop Clinic, staffed by personnel

of Fort Jackson's Medical Detachment. Again depending upon the problem, the individual may have been treated at the Troop Clinic or referred to Moncrief Army Community Hospital, the hospital on Fort Jackson.

The athletic trainer and medical personnel, except the medic at battalion sick call, entered each encounter in the trainee's electronic medical records. The information entered included the date of the sick call, the complaint, the diagnosis, an ICD-9-CM (International Classification of Diseases, 9th revision, Clinical Modification) code appropriate to the diagnosis, and the disposition of the case (i.e., full duty, restricted duty, hospitalization). If duty was restricted (i.e., an individual was put on profile), the nature of the restriction and its duration were entered. The durations of hospitalizations were also entered. Follow-up visits for a previously diagnosed problem were entered as they occurred. The author of this report queried the medical records of test participants regularly over the weeks of training for entries related to sick calls made for lower extremity complaints.

Completion of the Data Acquisition Phase of Testing

Four or five days prior to graduation, which marked the end of basic training, a questionnaire was administered to test participants asking about their experiences during training with the boots they had been issued. A copy of this questionnaire is in Appendix D. The test boots were visually inspected for signs of wear and damage at the time of questionnaire administration. One topic on the questionnaire pertained to the temperate weather combat boots. Following standard procedures, trainees returned to the CIIP during the seventh week of training to receive their Army dress uniforms. At that time, test participants were fitted for and issued one pair of temperate weather boots to fulfill their authorized allotment of boots. Thus, for approximately 2 weeks of training, test participants had the option of wearing temperate weather boots or the test boots (i.e., hot weather combat boots).

Sick call information from the medical records was acquired on study participants throughout the time the participants remained within the training battalion to which they were originally assigned. At Fort Jackson, all companies within a battalion graduate together. For each of the two battalions involved in the study, querying of the medical records of test participants continued for 5 days after the date of graduation to ensure completeness of the medical data through the day of graduation. Graduation of the first battalion occurred on December 11, 2009. For the second battalion, training was suspended on December 17, 2009, and the trainees were released for the end of the year holidays. Training was resumed on January 4, 2010. The second battalion graduated on January 22, 2010.

In the case of individuals removed from their original battalion prior to graduation, their sick call information was no longer recorded as study data. Depending upon the reason for removal, the individual could be discharged from service or reassigned to a different unit. Some individuals were discharged because of health conditions existing prior to service or an administrative reason, such as inability to perform training activities. Other individuals were removed from training because of illness or injury and were sent to the Physical Training and Rehabilitation Program for a period of recovery, after which they may have joined a new training unit or been discharged. Those participants who completed basic training successfully,

graduating with their original battalion, are referred to as Graduates in this report. Similarly, participants who did not graduate with their original battalion are referred to as Nongraduates.

Treatment of Test Data

Sources of Data

The principal source of the data presented in this report was the medical records of sick call visits made for lower extremity complaints. The date of the sick call, the trainee's complaint, the diagnosis, the ICD-9-CM code assigned, and the disposition of the case (i.e., full duty, restricted duty, hospitalization) were entered into the study database. If duty was restricted, the nature of the restriction and its duration were entered. The durations of any hospitalizations were also entered. In the course of a sick call visit, an individual may have been referred from one medical treatment provider to another (e.g., from an athletic trainer to the Troop Clinic Physical Therapy section). Those instances were entered as a single sick call in the study database.

The sick calls recorded for the study were those made for any complaint of a problem at or below the knee. Sick call entries in the database were categorized on the basis of the body site of the complaint using a classification scheme formulated by Barell et al. (2002) and modified by Hauret and his colleagues (Hauret, Jones, Bullock, Canham-Chervak, & Canada, 2010). If more than one site was involved, this was noted in categorizing the sick call. The determinations made by medical personnel during a sick call visit were categorized on the basis of whether an overuse injury was diagnosed. Overuse injuries were defined as conditions associated with repetitive microtrauma to a muscle, tendon, ligament, bone, joint, or surrounding tissue. The overuse injuries included specifically diagnosed conditions, such as stress fractures, tendinitis, and plantar fasciitis. They also included more general diagnoses of muscle strains and pain. Diagnoses related to such problems as blisters, ingrown nails, fungal infections, and contusions were not categorized as overuse injuries.

Other sources of data acquired in the study were responses on the two questionnaires administered to test participants. The questionnaire given at the beginning of the study period was used to obtain age, body weight and height, demographic information, and physical activity and injury histories (Appendix C). The subject areas probed on this questionnaire included those related to factors that have been found in past investigations to affect the risk of incurring an overuse injury of the lower extremities (Almeida et al., 1999; Jones et al., 1994; Jones et al., 1993). The questionnaire administered several days before graduation served as a means to ascertain the participants' experiences with their test boots (Appendix D). Further study information was obtained from the headquarters of the two battalions to which test participants were assigned. This information included rosters of company assignments and listings of individuals removed from training, along with the date and the reason for attrition from training.

Data Compilation and Analysis

In the current study, the women had a substantially higher incidence of injury than the men. This has been a consistent finding in investigations of the morbidity of U.S. Army basic

trainees to lower extremity injury and the finding has been documented in the published literature (Bensel & Kish, 1983; Knapik et al., 1999; Knapik et al., 2009). Given the availability of literature on gender differences in injuries among Army trainees, results of statistical analyses contrasting the data of the male and the female test participants are not presented in this report. For presentation here, the data of the men and the women have been analyzed separately to independently assess the effects on each gender of the test boots in the four sole constructions. Depending upon the particular variable being analyzed, the data were further subdivided by graduation status (i.e., Graduates, Nongraduates). Because of the relatively small number of Nongraduates within a sole construction group, most of the results presented pertain to Graduates and to all participants (i.e., the combined data of Graduates and Nongraduates).

A large number of the dependent variables compiled in the study were measured on nominal or ordinal scales, and the data for a variable consisted of frequencies in discrete categories (e.g., did attend sick call, did not attend sick call). These variables were analyzed using nonparametric statistical tests, mainly chi-square (χ^2) tests for homogeneity of proportions in independent samples (Marascuilo & McSweeney, 1985; Siegel & Castellan, 1988). The significance level was set at $p < .05$. Post hoc analyses were done if the main test achieved significance. The χ^2 statistical test was carried out to determine whether the four sole construction groups differed in terms of the measure being analyzed. The test contrasted the groups with respect to the relative frequency with which group members fell in the discrete categories comprising the variable (e.g., number of participants in each sole construction group who attended sick call, number of participants in each sole construction group who did not attend sick call).

An additional nonparametric analysis, a person-days analysis, was carried out on time to first overuse injury. A person-days analysis introduces a time base and is used in epidemiological research to calculate the incidence rate of a disease or a condition per person-day at risk (Kahn & Sempos, 1989). This form of analysis was used previously to study occurrences of lower extremity injuries among military trainees. Knapik et al. (2009) applied a person-days analysis in an investigation of injuries among Army trainees as affected by issuing running shoes based on plantar foot shape.

A definition of time to first injury was established by the author of this report for purposes of executing the person-days analysis. Time to first injury was defined as the training day on which medical personnel placed an individual on restricted duty for the first time to recuperate from an overuse injury of the lower extremities. Thus, a trainee's attendance at sick call for a lower extremity complaint met the definition only if: 1) the attending medical personnel diagnosed an overuse injury of the lower extremities; 2) the attending medical personnel issued a restriction on the trainee's activities to allow time for recuperation from the diagnosed injury; and 3) the trainee had not previously been placed on restricted duty status because of a lower extremity overuse injury.

Injury incidence rates, expressed as injuries per 1,000 trainees per day, were calculated as:

(Participants with ≥ 1 overuse injury) ÷ (total time in basic training x 1,000)

For those individuals who graduated basic training without having received at least one day of restricted duty for an overuse injury, total time in training was 65 days. For Nongraduates, total time in training was calculated to the day they ceased training.

In treating the questionnaires (Appendices C and D), compilation and analysis of the data for a given question were limited to the usable responses; participants with a missing response on that particular question were ignored. Therefore, in the presentations of questionnaire results, the number of respondents may vary from question to question and may not equal the number of test participants.

Date of birth was obtained on the questionnaire administered at the time individuals consented for study participation (Appendix C) and was used to calculate a participant's age to the date he or she consented for the study. A participant's height and weight were obtained on this questionnaire, as well, and were used to calculate body mass index (BMI). The BMI was calculated as Weight/Height^2 and expressed in $kg \cdot m^{-2}$. Age, height, weight, and BMI are continuous measures and were subjected to separate one-way, completely randomized analyses of variance (ANOVAs) to determine whether the four sole construction groups differed on any of these variables. Significance level for the ANOVAs was set at $p < .05$. Where a significant F ratio was obtained, a post hoc test in the form of the Tukey Honestly Significant Difference procedure was applied.

As indicated previously, participants' heights and weights analyzed in this study were not measured, but, rather, were self-reported. Self-report is a frequently used method for obtaining this information, and the validity of height and weight data acquired in this manner has been the subject of a number of research studies. Investigators have found that self-reported height and weight are highly correlated with the actual measured values (Spencer, Appleby, Davey, & Key, 2002), but that there are systematic reporting errors influenced by a number of factors, including gender (Rowland, 1990; Stunkard & Albaum, 1981; Villanueva, 2001). The results of research have indicated that men overestimate their weight, whereas women underestimate theirs, and that both genders overestimate their height (Rowland, 1990; Villanueva, 2001). Different investigators have obtained different values of over- and underestimates, depending upon the particular populations under study, but the average amounts are relatively small. For example, studies have found overestimation of weight by men to average 0.4-0.5 kg (0.9-1.1 lb) and underestimation of weight by women to average 1.0-1.5 kg (2.2-3.3 lb; Rowland, 1990; Villanueva, 2001). With regard to height, overestimates averaging 1.2-1.4 cm (0.5-0.6 in.) have been reported for men and overestimates averaging 0.6 cm (0.2 in.) have been reported for women (Rowland, 1990; Spencer et al., 2002).

Based on the research into the validity of self-reported height and weight, it is not expected that the height and weight data presented in this study are as accurate as data obtained through direct measurement would be. However, on average, the over- and underestimates reflected in the self-reported data are likely to be small. Further, the amounts by which the self-reported heights and weights differ from actual values are likely to be approximately equal across the four sole construction groups.

RESULTS

Composition of the Sole Construction Groups

Once an individual consented to take part in the current study, enrollment as a participant was contingent upon the individual being successfully fitted for and issued one of the four types of test boots and then beginning basic training with one of the two battalions involved in the testing. Table 2 is an outline of steps in the formation of the sole construction groups and the number of men and women processed at each step. The entries in the last row of the table are the number of men and of women who met the two criteria and were enrolled as study participants.

Table 2
Stages in the Formation of Sole Construction Groups and the Number of Trainees Involved in Each Stage

	Men					Women				
Stage	DMS	WLT	A-R	A-P	Tot.	DMS	WLT	A-R	A-P	Tot.
1. Briefed and consented	--	--	--	--	1312	--	--	--	--	772
2. Received test boots	301	263	249	242	1055	119	86	102	92	399
3. Started basic training[a]	291	258	239	240	1028	116	85	97	90	388

[a]Entries in this row are the numbers of male and female test participants comprising the sole construction groups.

To assess the comparability of the sole construction groups at the start of testing, analyses were carried out to determine whether the individuals comprising the groups, including both Graduates and Nongraduates, differed in age, height, weight, or BMI. Age, height, and weight were obtained from the questionnaires completed at the time participants consented to take part in the study (Appendix C), and BMI was calculated from the self-reported height and weight. The ANOVAs applied to analyze theses variables yielded only one significant effect ($p < .01$). This was for the men on BMI (Table 3). Findings from post hoc tests indicated that the significant effect was attributable to a difference between the sole construction group with the highest BMI, the WLT group, and the group with the lowest BMI, the A-R group. Although the finding was significant, the difference between the means for the two groups was small, 1 $kg \cdot m^{-2}$ (Table 3).

Further assessment of the comparability of the sole construction groups at the time of study initiation was carried out by analyzing for group differences in responses to other topics included on the questionnaire administered at the time participants consented for the study (Appendix C). These questionnaire responses, combining the data of the Graduates and the Nongraduates, are in Table 4 along with the findings from the χ^2 tests. As indicated in the table, there were no significant differences ($p > .05$) among sole construction groups in the analyses of the men's or the women's responses.

Table 3
Summary Statistics for Age and Physical Characteristics of the Men and Women in Each Sole Construction Group and Results of Comparative Analyses Among Groups

		Men					Women				
Variable	Statistic	DMS	WLT	A-R	A-P	p[a]	DMS	WLT	A-R	A-P	p[a]
Age (years)	Mean	22.8	23.4	22.9	22.5		22.7	23.5	23.2	23.5	
	Std. Dev.	4.1	5.0	4.6	4.5	> .05	4.9	5.7	4.5	5.6	> .05
	n	291	258	239	240		116	85	97	90	
Height, self-reported (m)	Mean	1.8	1.8	1.8	1.8		1.6	1.7	1.6	1.6	
	Std. Dev.	0.1	0.1	0.1	0.1	> .05	0.1	0.1	0.1	0.1	> .05
	n	287	256	236	238		115	85	97	89	
Weight, self-reported (kg)	Mean	80.5	82.7	80.4	81.7		63.5	66.0	65.0	65.5	
	Std. Dev.	14.1	14.4	14.1	13.6	> .05	9.4	9.0	9.8	9.2	> .05
	n	289	256	237	237		115	84	96	89	
BMI, calculated from self-reported ht and wt ($kg \cdot m^{-2}$)	Mean	**25.5**	**26.3**	**25.3**	**26.0**		23.5	24.1	24.0	24.1	
	Std. Dev.	**4.1**	**3.9**	**3.7**	**4.1**	**< .01**	3.4	3.2	3.0	2.9	> .05
		AB	**A**	**B**	**AB**						
	n	**285**	**254**	**234**	**235**		114	84	96	89	

Note. The combined data of Graduates and Nongraduates are included here.
[a]Significance level of ANOVA F ratio for the main effect of sole construction. Where $p < .05$ or better, the relevant data are bolded, and the results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

Table 4
Percentages of Men and Women in Each Sole Construction Group Selecting Response Options on the Questionnaire Administered at Initiation of Testing and Results of Comparative Analyses Among Groups

		Men					Women				
Question Topic	Response Option	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p[a]	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p[a]
Race	White	66.5	69.1	67.6	62.9		55.4	55.1	46.0	52.3	
	Black	18.3	11.8	17.3	16.5		31.8	32.0	36.8	31.3	
	Hispanic	12.3	13.8	13.3	15.2	> .05	10.9	9.0	16.1	12.8	> .05
	Asian	2.8	5.3	1.8	5.4		1.8	3.8	1.1	3.5	
	n	284	246	225	224		110	78	87	86	
Service Component	Regular Army	60.9	56.0	60.8	59.5		45.7	63.1	56.7	48.3	
	Army Reserve	15.9	14.4	12.6	13.1		15.5	14.3	15.5	19.1	
	National Guard	23.2	29.6	26.6	27.4	> .05	38.8	22.6	27.8	32.6	> .05
	n	289	257	237	237		116	84	97	89	
Education Level	Completed HS/GED	48.0	52.2	57.2	55.3		51.4	48.7	47.2	55.8	
	Some College	34.2	34.1	27.5	28.9		36.4	23.7	27.5	23.4	
	Completed College	14.9	10.0	13.5	11.9	> .05	11.2	13.2	16.5	11.7	> .05
	Some Post-College	2.8	3.6	1.7	3.8		1.0	14.5	8.8	9.1	
	n	281	249	229	235		107	76	91	77	
Shoes worn most often, past 12 months	Low heel leather	5.7	8.2	5.4	5.4		3.2	2.9	6.2	5.3	
	Running shoe/sneaker	82.4	81.8	85.0	86.5		67.7	73.9	63.0	56.0	
	Boot	6.5	7.8	7.7	5.4	> .05	1.1	0.0	2.5	1.3	> .05
	Sandal	5.4	2.2	1.8	2.7		18.3	14.5	11.1	24.0	
	High heel leather	--	--	--	--		9.7	8.7	17.3	13.3	
	n	261	231	220	222		93	69	81	75	
Smoking habits	Never smoked	61.1	56.3	65.1	61.5		68.1	72.6	62.8	58.6	
	Smoked; quit > 12 months	10.0	9.5	12.6	9.0		2.6	1.2	10.7	9.2	
	Smoked; quit < 12 months	13.6	17.1	13.4	11.5	> .05	12.1	13.1	10.7	12.6	> .05
	Smoke currently	15.4	17.1	8.8	18.0		17.2	13.1	16.0	19.5	
	n	280	252	238	234		116	84	94	87	
Surgery in the past for accident/injury	Yes	9.0	9.7	6.3	10.1		4.3	5.9	5.2	6.7	
	No	91.0	90.3	93.7	89.9	> .05	95.6	94.1	94.8	93.2	> .05
	n	290	257	239	238		115	85	96	89	

Table 4 (cont'd)

Question Topic	Response Option	Men DMS (%)	Men WLT (%)	Men A-R (%)	Men A-P (%)	Men p^a	Women DMS (%)	Women WLT (%)	Women A-R (%)	Women A-P (%)	Women p^a
Medical waiver for enlistment	Yes	12.5	13.5	7.8	11.1		9.6	16.7	13.7	13.3	
	No	87.4	86.4	92.2	88.9	> .05	90.4	83.3	86.3	86.7	> .05
	n	287	251	231	234		114	84	95	90	
Physical activity level	Somewhat/very inactive	10.0	12.4	11.8	6.7		8.6	15.7	10.3	16.8	
	Average	29.1	26.7	27.0	24.7		41.4	32.5	27.8	29.2	
	Somewhat/very active	60.9	60.8	61.2	68.6	> .05	50.0	51.8	61.8	53.9	> .05
	n	289	258	237	239		116	83	97	89	
Physical ability/fitness compared with peers	Somewhat/much below average	12.4	10.1	14.3	7.5		14.6	15.7	8.2	16.8	
	Average	41.5	49.8	38.4	46.0	> .05	56.9	55.4	60.8	52.8	> .05
	Somewhat/much above average	46.0	40.1	47.2	46.4		28.4	28.9	30.9	30.3	
	n	289	257	237	239		116	83	97	89	
Play varsity sports	Yes	53.3	46.7	51.5	54.8		51.7	34.9	42.3	46.7	
	No	46.7	53.3	48.5	48.4	> .05	48.3	65.1	57.7	53.3	> .05
	n	289	257	237	239		116	83	97	90	
In last 2 months, frequency/week of exercise/ sports for >30 min	< 1 time	7.6	8.2	7.2	7.2		8.6	8.2	11.6	6.7	
	1 time	18.4	11.8	17.0	12.2		14.6	12.9	13.7	16.7	
	2-3 times	43.4	41.6	42.1	44.7	> .05	44.0	44.7	55.8	44.4	> .05
	4-5 times	30.5	38.4	33.6	35.8		32.8	34.1	18.9	32.2	
	n	288	255	235	237		116	85	95	90	
In last 2 months, frequency/week of running/ jogging	None	6.2	7.8	6.8	3.8		10.3	4.7	8.4	4.5	
	1-2 days	45.0	37.6	40.4	44.9		40.5	47.0	45.3	41.6	
	3-4 days	37.7	39.2	37.0	39.8	> .05	33.6	35.3	38.9	39.3	> .05
	≥ 5 days	11.1	15.3	15.7	11.4		15.5	12.9	7.4	14.6	
	n	289	255	235	236		116	85	95	89	
In last 2 months, frequency/week of weight training	None	30.4	26.1	34.6	33.0		48.7	41.2	42.7	42.0	
	1-2 days	38.8	37.5	37.2	36.0		29.6	40.0	40.6	36.4	
	3-4 days	21.1	26.5	20.1	22.0	> .05	18.3	14.1	12.5	18.2	> .05
	≥ 5 days	9.7	9.9	8.1	8.9		3.5	4.7	4.2	3.4	
	n	289	253	234	236		115	85	96	88	

Table 4 (cont'd)

Question Topic	Response Option	Men DMS (%)	Men WLT (%)	Men A-R (%)	Men A-P (%)	Men p[a]	Women DMS (%)	Women WLT (%)	Women A-R (%)	Women A-P (%)	Women p[a]
Exercise/sports in last 2 months compared with usual level	Somewhat/much less	15.6	9.8	15.3	14.3		21.6	10.7	20.8	21.1	
	Same amount	29.8	32.5	29.8	28.7		16.4	29.8	24.0	23.3	
	Somewhat/much more	54.7	57.6	54.9	57.0	> .05	62.1	59.5	55.2	55.6	> .05
	n	289	255	235	237		116	84	96	90	
≥ 1 pregnancy	Yes						33.6	25.3	28.3	33.3	
	No						66.4	74.7	71.7	66.7	> .05
	n						116	83	92	87	
Birth control/ hormones in last 12 months	Yes						41.4	37.0	47.2	42.0	
	No						58.6	63.0	52.7	58.0	> .05
	n						116	81	91	88	

Note. The combined data of Graduates and Nongraduates are included here.
[a]Significance level of χ^2 test comparing sole construction groups.

Examination of the data in Table 4 reveals that the distributions of the men's responses to the questions were highly similar across sole construction groups. On several of the questions, the women's responses revealed less similarity across groups. For example, the DMS and the A-P groups had higher proportions of women in the National Guard and lower proportions of women in the Regular Army compared with the WLT and the A-R groups (Table 4). With regard to the women's smoking habits, 73% of the WLT and 68% of the DMS groups had never smoked versus 63% of the A-R and 59% of the A-P groups. Sixty-two percent of the women in the A-R group rated themselves as somewhat or very physically active compared with approximately 50% of the members of the other groups. In terms of the women's regular exercise over the last 2 months, however, a lower proportion of the A-R group reported engaging in exercise as frequently as 4 to 5 days per week compared with the other sole construction groups (Table 4). Although the women's data revealed some differences among groups in responses on the questionnaire, the differences were not statistically significant ($p > .05$).

Boot Sizes Issued

The sizes issued in each type of test boot are presented in Tables 5 and 6 for the men and the women, respectively. The entries in the cells are the percentages of individuals given a particular size out of the total number of male or female members of each sole construction group. The number of different sizes issued to the men ranged from 29 in the A-P boots to 36 in the DMS boots. For the women, the different sizes issued ranged from 24 for the DMS and the A-P boots to 28 for the A-R boots. Also shown in Tables 5 and 6 for each test boot type are the sizes that were exhausted from the stock of boots on hand for the study (Appendix B).

As is indicated in Table 2, slightly over half the women who consented to participate in the study were issued test boots, whereas 80% of the men who consented received test boots. The difficulty in outfitting women in test boots was attributable at least in part to a lack of stock in appropriate sizes. It can be seen in Tables 5 and 6 that the supplies of sizes at the smaller end of the size range were more likely to be exhausted than those at the higher end of the range. The possibility that the test boots did not provide an adequate fit on women cannot be ruled out as a reason for the high proportion of women who tried test boots and were not issued them. However, the daily record of processing provides some evidence that women were fit in the test boots successfully when sizes at the lower end of the range were available. During the earliest days of the study initiation phase, when the boot stock was at its highest point, between 83 and 93% of the women who consented to participate in the study on any day were issued test boots, as were between 82 and 100% of the men. The percentage of women issued boots on any given day out of those who consented to participate fell to less than 20% toward the end of the study initiation phase; comparable values for the men at that time remained above 50%.

The personnel at the Fort Jackson CIIP who did the fitting of the test boots maintained that the four types of boots fit differently. Examination of predicted sizes measured with the Brannock Foot Measuring Device versus boot sizes issued did reveal differences among the sole construction types that may be reflective of differences in fit. Table 7 is a summary of the length and width of the boots issued to participants in each sole construction group relative to predicted length and width. The χ^2 test applied to the women's data revealed a significant difference ($p < .02$) among groups in predicted versus issued length. The men's data did not yield a significant

difference ($p > .05$) on this metric. Post hoc analysis of the women's data indicated that the A-R group differed from the other three; the A-R group had a higher proportion of issued sizes that were shorter than the predicted and a lower proportion that were the same as the predicted, compared with the other three sole construction groups.

Table 5
Sizes Issued to the Men in Each Sole Construction Group as a Percentage of the Total Number of Men in a Group

		Sole Construction Type						Sole Construction Type			
Size		DMS (%)	WLT (%)	A-R (%)	A-P (%)	Size		DMS (%)	WLT (%)	A-R (%)	A-P (%)
4	R					9	R	6.2	6.2	7.5	6.7
	W						W	7.6	8.5	6.7	7.1
	XW						XW	0.3	0.4	0.4	
4½	R					9½	R	7.9	8.1	9.2	8.8
	W						W	7.2	4.7	3.8	5.4
	XW						XW	1.4		0.4	
5	R			0.4		10	R	7.2	9.3	9.2	9.2
	W						W	6.6	5.4	3.8	4.6
	XW		0.8	0.4	0.4		XW		0.4		
5½	R					10½	R	7.2	7.0	8.4	8.8
	W			0.8			W	3.8	1.2	1.3	0.4
	XW			0.4	0.4		XW	0.3			
6	R	0.3				11	R	4.8	5.4	5.4	6.3
	W	0.7	0.4				W	3.1	0.4	0.8	0.4
	XW						XW				
6½	R		0.4			11½	R	3.1	3.5	3.8	4.2
	W		2.3	0.8	0.8		W	1.0		0.8	0.8
	XW		0.4	0.4			XW				
7	R	0.3	1.9	0.4	0.4	12	R	2.4	1.9	3.8	1.7
	W	1.4	2.3	1.3	1.7		W				
	XW	2.1	1.9	0.8	0.4						
7½	R	0.7	1.6	2.5	2.5	12½	R	1.0	1.2	2.1	0.8
	W	2.8	3.1	1.7	3.3		W				
	XW	1.7	1.6	1.3	0.8						
8	R	2.4	2.7	2.5	2.5	13	R		0.4	1.3	1.3
	W	3.8	4.7	5.9	6.3		W	0.3		0.4	
	XW	2.1	0.8	0.8	0.8						
8½	R	3.8	3.9	5.0	5.4		*n*	290	258	239	240
	W	6.2	7.0	5.0	7.9						
	XW		0.4	0.4							

Note. Shaded cells indicate that all boots on hand in that size and sole construction were issued.

Table 6

Sizes Issued to the Women in Each Sole Construction Group as a Percentage of the Total Number of Women in a Group

	Sole Construction Type					Sole Construction Type			
Size	DMS (%)	WLT (%)	A-R (%)	A-P (%)	Size	DMS (%)	WLT (%)	A-R (%)	A-P (%)
4 R	2.6	3.5	1.0	2.2	9 R		2.4		1.1
W	2.6	2.4	3.1	3.4	W	0.9		1.0	
XW	4.3	1.2	6.3	2.2	XW				
4½ R	2.6	2.4	3.1	3.4	9½ R		1.2		1.1
W	5.2	7.1	6.3	6.7	W				
XW	2.6	3.5	3.1	2.2	XW				
5 R	2.6	1.2	2.1	3.4	10 R				
W	5.2	7.1	6.3	6.7	W				
XW	4.3		4.2	1.1	XW				
5½ R	2.6	3.5	2.1	3.4	10½ R				
W	5.2	7.1	4.2	6.7	W				
XW	2.6				XW				
6 R	4.3	5.9	5.2	6.7	11 R				
W	6.1	9.4	9.4	10.1	W				
XW	2.6	2.4	1.0		XW				
6½ R	4.3	5.9	6.3	4.5	11½ R				
W	7.8	3.5	7.3	7.9	W				
XW	0.9	2.4			XW				
7 R	2.6	1.2	4.2	5.6	12 R				
W	3.5	3.5	5.2	5.6	W				
XW				1.1					
7½ R	6.1	4.7	3.1	3.4	12½ R				
W	3.5	3.5	5.2	4.5	W				
XW									
8 R	4.3	5.9	6.3	5.6	13 R				
W	3.5	3.5	1.0		W				
XW									
8½ R	3.5	5.9	3.1	1.1	*n*	115	85	96	89
W	2.6								
XW	0.9								

Note. Shaded cells indicate that all boots on hand in that size and sole construction were issued.

Table 7

Length and Width of Issued Size Relative to Length and Width of Predicted Size for Men and Women in Each Sole Construction Group and Results of Comparative Analyses Among Groups

		Men					Women				
Size Category	Issued Relative to Predicted	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^a	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^a
Issued Length	Shorter	35.9	34.9	37.6	41.7		**23.5**	**32.9**	**45.8**	**32.6**	
	Same	59.6	60.8	58.6	54.6		**67.0**	**61.2**	**47.9**	**65.2**	
	Longer	4.5	4.3	3.8	3.7	> .05	**9.6**	**5.9**	**6.2**	**2.2**	**< .02**
							A	**A**	**B**	**A**	
	n	290	258	239	240		115	85	96	89	
Issued Width	Narrower	**2.4**	**7.0**	**3.8**	**3.8**		**0.9**	**8.2**	**5.2**	**12.4**	
	Same	**73.1**	**80.2**	**83.7**	**83.3**		**65.2**	**78.8**	**66.7**	**71.9**	
	Wider	**24.5**	**12.8**	**12.6**	**12.9**	**< .001**	**33.9**	**12.9**	**28.1**	**15.7**	**< .001**
		A	**B**	**B**	**B**		**A**	**B**	**A**	**B**	
	n	290	258	239	240		115	85	96	89	

Note. The combined data of Graduates and Nongraduates are included here.
[a]Significance level of χ^2 test comparing sole construction groups. Where $p < .05$ or better, the relevant data are bolded, and the results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

For predicted versus issued width, the χ^2 tests yielded significant differences ($p < .001$) among sole construction groups in the analyses of both the men's and the women's data (Table 7). Post hoc tests for the men's data indicated that the DMS group had a lower proportion of issued widths that were the same as the predicted width and a higher proportion of issued widths that were wider than the predicted width (Table 7). Post hoc tests on the women's data yielded similar results. However, for the women's data, both the DMS and the A-R groups had a lower proportion of issued widths that were the same as the predicted widths and a higher proportion that were wider than the predicted compared with the WLT and the A-P groups (Table 7).

Attrition From Basic Training

Twenty-seven male participants (3% of the men in the study) and 33 female participants (8% of the women in the study) failed to complete training with the battalion to which they were originally assigned. The number of these Nongraduates in each sole construction group is presented in Table 8. For the men, the A-R group had the highest proportion of Nongraduates and the A-P group had the lowest. For the women, the highest proportion of Nongraduates was in the A-P group and the lowest in the A-R. The χ^2 test was applied to determine whether the groups differed in the percentage of Nongraduates. The test did not reveal significant differences ($p > .05$) among the groups for either the men's or the women's data (Table 8).

Attrition was attributable to administrative reasons, illness, or injury. The number of Nongraduates whose attrition from training was specifically attributable to overuse injuries of the lower extremities is in Table 8. Medical conditions deemed to have existed prior to an individual entering the Army were excluded from the count. Out of all participants, the training of two men and three women was terminated prior to graduation because of overuse injuries of the lower extremities. The men were diagnosed for tibial stress fractures and the women for metatarsal stress fractures. In each case, the individual was assigned to the Physical Training and Rehabilitation Program for a period of rehabilitation.

Sick Call Visits

Attendance at sick calls represents loss of time available for engaging in basic training activities. The proportion of test participants who attended at least one sick call for some complaint related to the knee, shank, ankle, or foot and the total number of sick calls these individuals made were analyzed to compare sole construction groups. The sick call related data for the Graduates and for the Graduates and Nongraduates combined as a function of sole construction worn are presented in Table 9. As indicated in the table, 16% and 39% of the male and the female Graduates, respectively, and slightly higher percentages of the Graduates and the Nongraduates combined attended sick call at least once with some lower extremity complaint.

Table 8
Number (and Percentage) of Graduates and Nongraduates Among Men and Women in Each Sole Construction Group

Status		Men[a]						Women[b]					
		All Grps.	DMS	WLT	A-R	A-P	p^c	All Grps.	DMS	WLT	A-R	A-P	p^c
Nongraduates													
	Any reason	27 (2.6)	7 (2.4)	7 (2.7)	9 (3.8)	4 (1.7)	> .05	33 (8.5)	9 (7.8)	7 (8.2)	5 (5.2)	12 (13.3)	> .05
	Lower extremity overuse	2 (0.2)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)		3 (0.8)	1 (0.9)	0 (0.0)	0 (0.0)	2 (2.2)	
Graduates		1001 (97.4)	284 (97.6)	251 (97.3)	230 (96.2)	236 (98.3)		355 (91.5)	107 (92.2)	78 (91.8)	92 (94.8)	78 (86.7)	

[a]Number of male participants: All groups, n = 1028; DMS, n = 291; WLT, n = 258; A-R, n = 239; A-P, n = 240.
[b]Number of female participants: All groups, n = 388; DMS, n = 116; WLT, n = 85; A-R, n = 97; A-P, n = 90.
[c]Significance level of χ^2 test comparing sole construction groups.

Table 9
Percentage of Participants in Each Sole Construction Group Attending at Least One Sick Call for a Complaint Related to the Knee, Shank, Ankle, or Foot and Average (Median) Number of Sick Call Visits Made by These Participants

	Graduates[a]						Graduates + Nongraduates[b]					
Sick Call Visits	All Grps.	DMS	WLT	A-R	A-P	p[c]	All Grps.	DMS	WLT	A-R	A-P	p[c]
Men												
≥ 1 visit (%)	16.3	15.5	16.7	13.9	19.1	> .05	17.5	17.2	18.3	15.5	19.2	> .05
Median number of visits	1.4	1.3	1.5	1.3	1.4	> .05	1.4	1.4	1.4	1.4	1.5	> .05
Women												
≥ 1 visit (%)	38.6	**48.6** **A**	**30.8** **AB**	**26.1** **B**	**47.4** **A**	**< .01**	41.0	**50.9** **AC**	**31.8** **AB**	**26.8** **B**	**52.2** **C**	**< .001**
Median number of visits	1.8	1.8	2.0	1.8	1.6	> .05	1.9	1.9	2.0	1.9	1.9	> .05

[a]Number of male Graduates in all groups combined: n = 1001. Number of male Graduates in each sole construction group: DMS, n = 284; WLT, n = 251; A-R, n = 230; A-P, n = 236. Number of female Graduates in all groups combined: n = 355. Number of female Graduates in each sole construction group: DMS, n = 107; WLT, n = 78; A-R, n = 92; A-P, n = 78.
[b]Number of male participants in all groups combined: n = 1028. Number of male participants in each sole construction group: DMS, n = 291; WLT, n = 258; A-R, n = 239; A-P, n = 240. Number of female participants in all groups combined: n = 388. Number of female participants in each sole construction group: DMS, n = 116; WLT, n = 85; A-R, n = 97; A-P, n = 90.
[c]Significance levels of χ^2 tests comparing sole construction groups. Where p < .05 or better, the relevant data are bolded, and the results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

In terms of sole construction effects, the men's data did not yield significant differences ($p > .05$) among sole construction groups in the proportion of participants who attended sick call at least once for a lower extremity complaint (Table 9). Further, the median number of sick calls made by those men attending sick call at least once for a lower extremity problem did not differ significantly ($p > .05$) among the sole construction groups. The results of analysis of the women's data were similar insofar as there was no significant difference among groups in the median number of sick calls made. However, the data of the female Graduates and the combined data of the female Graduates and Nongraduates revealed that the proportion of participants attending one or more sick calls for a lower extremity complaint differed significantly ($p < .05$ or better) with the test boot used (Table 9).

For the female Graduates, the percentage who attended one or more sick calls for some lower extremity complaint was lowest in the A-R group and highest in the DMS and the A-P groups. Post hoc analysis revealed that the DMS and the A-P groups did not differ significantly from each other in sick call attendance, but both differed significantly from the A-R group. The WLT group was not significantly different from the three other groups (Table 9). For the combined data of the female Graduates and Nongraduates, the percentage of women attending sick call at least once for a lower extremity complaint was again lowest in the A-R group and highest in the DMS and the A-P groups. Post hoc analysis revealed that the A-R group differed significantly from the DMS and the A-P groups and that the DMS and the A-R groups did not differ from each other. The percentage of the WLT group attending sick call at least once was slightly higher, but not significantly so ($p > .05$), than the percentage in the A-R group. Also, the WLT group did not differ significantly from the DMS, but it was significantly lower than the A-P group (Table 9).

Figure 5 is a graphic presentation of the proportions of men and of women in each sole construction group who attended one or more sick calls for some lower extremity complaint. The data in the figure are for the Graduates and the Nongraduates combined.

Restricted Duty

A sick call visit for a lower extremity complaint could result in an individual being judged fit by the attending medical personnel to engage fully in all training activities. On the other hand, medical personnel could prescribe a day or more of recuperation (i.e., put the individual on profile), restricting the individual from engaging in some or all training activities for a period of time. Thus, to an even greater extent than a sick call visit, days of restricted duty represent time lost from full participation in training activities. The sick call data were examined for diagnoses made of overuse injuries occurring at or below the knee, and the days of restricted duty prescribed for recuperation were tallied. Table 10 contains the data pertaining to restricted duty associated with diagnoses of overuse injuries. As indicated in the table, 9% of the male Graduates and 27% of the female Graduates had at least one day of restricted duty attributable to a diagnosis of overuse injury. The percentages for the Graduates and the Nongraduates combined were slightly higher.

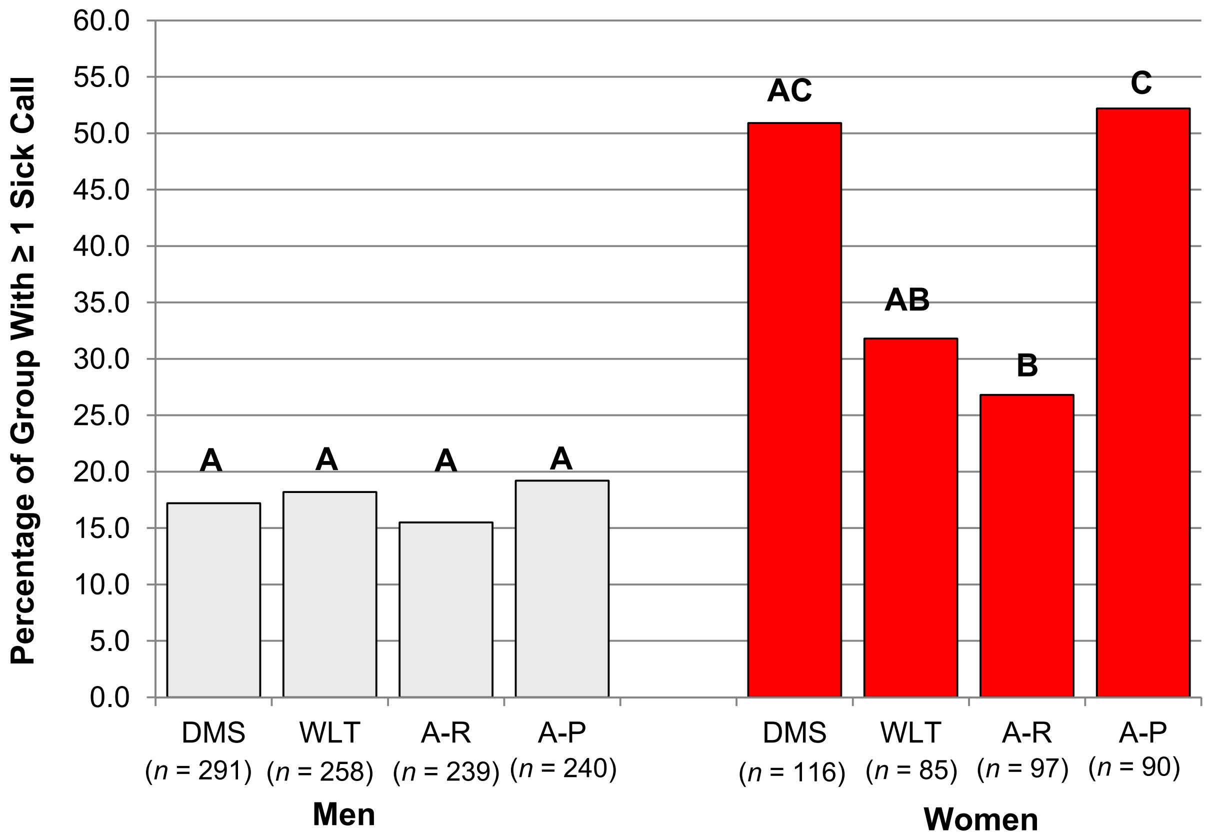

Figure 5. Percentage of each sole construction group with at least one sick call for a complaint involving the knee, shank, ankle, or foot. The data of both Graduates and Nongraduates are included. Within a gender, groups that do not share the same letters were significantly different at $p < .05$ or better on post hoc tests.

As was also the case with the analyses of the number of sick calls, the men's and the women's data did not yield significant differences ($p > .05$) among sole construction groups in the median number of days of restricted training. Further, for the male and the female Graduates, as well as for the combined data of the male Graduates and Nongraduates, the percentage of participants receiving at least one restricted day was not significantly affected by sole construction group assignment (Table 10). However, the combined data of the female Graduates and Nongraduates revealed significant differences ($p < .02$) among sole construction groups. The proportion of women who had one or more days of restricted duty was lowest in the WLT group and highest in the A-P group. Post hoc tests indicated that the difference between these two groups was significant. Although there were no other statistically significant differences among groups, the percentage of women in the A-R group who had at least one restricted day was only slightly higher than the percentage in the WLT group.

The men's and the women's data for the proportions of participants with at least one day of restricted duty are presented graphically in Figure 6. The data plotted are for the Graduates and Nongraduates combined.

Table 10
Percentage of Participants in Each Sole Construction Group Receiving at Least One Day of Restricted Duty for Overuse Injury Diagnosis Related to the Knee, Shank, Ankle, or Foot and Average (Median) Number of Restricted Days Received by These Participants

	Graduates[a]						Graduates + Nongraduates[b]					
Restricted Duty	All Grps.	DMS	WLT	A-R	A-P	p^c	All Grps.	DMS	WLT	A-R	A-P	p^c
Men												
≥ 1 restricted day (%)	9.3	9.5	10.4	6.5	10.6	> .05	10.1	10.6	10.8	7.9	10.8	> .05
Median number of restricted days	4.4	4.3	4.6	4.3	4.2	> .05	4.4	4.4	4.4	4.7	4.3	> .05
Women												
≥ 1 restricted day (%)	27.0	29.9	20.5	22.8	34.6	> .05	29.4	**31.0 AB**	**21.2 A**	**23.7 AB**	**41.1 B**	**< .02**
Median number of restricted days	5.7	6.2	5.5	6.0	4.8	> .05	6.5	6.8	5.5	7.0	4.8	> .05

[a]Number of male Graduates in all groups combined: *n* = 1001. Number of male Graduates in each sole construction group: DMS, *n* = 284; WLT, *n* = 251; A-R, *n* = 230; A-P, *n* = 236. Number of female Graduates in all groups combined: *n* = 355. Number of female Graduates in each sole construction group: DMS, *n* = 107; WLT, *n* = 78; A-R, *n* = 92; A-P, *n* = 78.
[b]Number of male participants in all groups combined: *n* = 1028. Number of male participants in each sole construction group: DMS, *n* = 291; WLT, *n* = 258; A-R, *n* = 239; A-P, *n* = 240. Number of female participants in all groups combined: *n* = 388. Number of female participants in each sole construction group: DMS, *n* = 116; WLT, *n* = 85; A-R, *n* = 97; A-P, *n* = 90.
[c]Significance levels of χ^2 tests comparing sole construction groups. Where $p < .05$ or better, the relevant data are bolded, and the results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

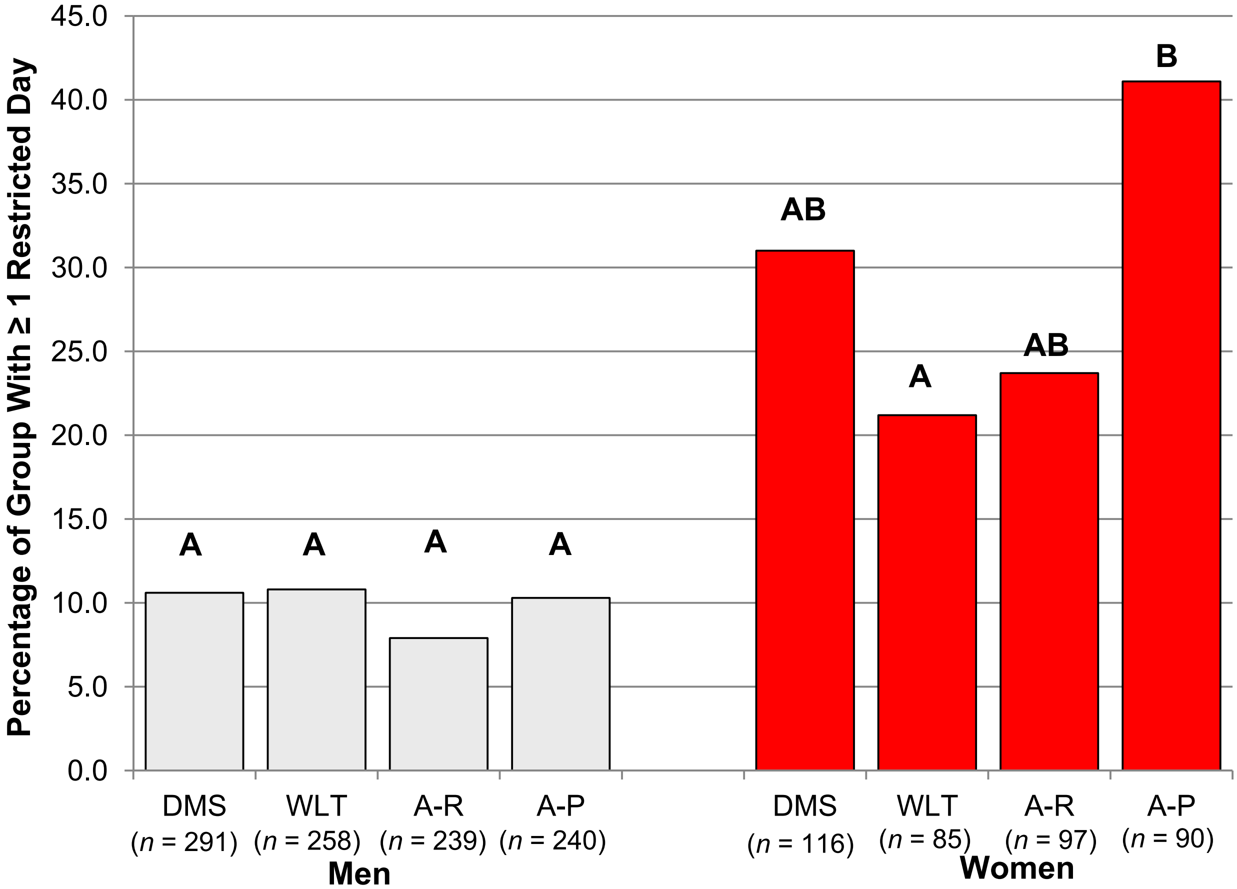

Figure 6. Percentage of each sole construction group with at least one day of restricted duty for an overuse injury diagnosis related to the knee, shank, ankle, or foot. The data of both Graduates and Nongraduates are included. Within a gender, groups that do not share the same letters were significantly different at $p < .05$ or better on post hoc tests.

Overuse Injuries

Several approaches were used to compare the sole construction groups with regard to diagnoses of overuse injuries at or below the knee. One approach was the person-days analysis carried out on time to first injury. The overuse injury incidence rates obtained for each sole construction group are listed in Table 11. These are expressed as injuries per 1,000 trainees per day spent in training. It can be seen in the table that the men's incidence rates in the four sole construction groups were similar. The women's data yielded greater differences among the groups, with the WLT having the lowest and the A-P having the highest incidence rates.

Table 11 also contains the rate ratios, which are the ratios of incidence rates for each pairwise combination of sole construction types, and the 95% confidence interval (CI) for each ratio. A χ^2 statistical test was done on each rate ratio to determine whether the two groups forming the ratio differed significantly in overuse injury incidence rates. One significant difference ($p < .05$) was obtained. The significant χ^2 was found for the women's data in the contrast between the sole constructions with the lowest and the highest incidence rates, the WLT and the A-P constructions, respectively (Table 11).

Table 11
Overuse Injury Incidence Rates for Male and Female Graduates and Nongraduates and Results of Pairwise Comparisons Between Sole Construction Groups

		Sole Construction Type							
		DMS		WLT		A-R		A-P	
Sole Construction Type	Injury Incidence Rate (Injuries/1,000 trainees/day)	Rate Ratio (95% CI) [RR Num/ RR Denom]	*p*[a]	Rate Ratio (95% CI) [RR Num/ RR Denom]	*p*[a]	Rate Ratio (95% CI) [RR Num/ RR Denom]	*p*[a]	Rate Ratio (95% CI) [RR Num/ RR Denom]	*p*[a]
Men[b]									
DMS	1.67	—		0.93 (0.56-1.56) [DMS/WLT]	> .05	1.31 (0.73-2.31) [DMS/A-R]	> .05	0.95 (0.56-1.61) [DMS/A-P]	> .05
WLT	1.80			—		1.40 (0.78-2.50) [WLT/A-R]	> .05	1.02 (0.60-1.74) [WLT/A-P]	> .05
A-R	1.28					—		0.73 (0.40-1.31) [A-R/A-P]	> .05
A-P	1.76							—	
Women[c]									
DMS	5.64	—		1.34 (0.77-2.35) [DMS/WLT]	> .05	1.05 (0.62-1.80) [DMS/A-R]	> .05	0.69 (0.43-1.10) [DMS/A-P]	> .05
WLT	4.15			—		0.80 (0.44-1.48) [WLT/A-R]	> .05	**0.52 (0.30-0.91) [WLT/A-P]**	**< .05**
A-R	5.21					—		0.66 (0.39-1.11) [A-R/A-P]	> .05
A-P	8.18							—	

Note. The sole construction types forming the numerator and the denominator of each rate ratio are indicated in brackets. The 95% CIs for the rate ratios are in parentheses.
[a]Significance levels of χ^2 tests for pairwise comparison of injury incidence rates between sole construction groups. Where $p < .05$ or better, the relevant data are bolded.
[b]Number of male participants in each sole construction group: DMS, $n = 291$; WLT, $n = 258$; A-R, $n = 239$; A-P, $n = 240$.
[c]Number of female participants in each sole construction group: DMS, $n = 116$; WLT, $n = 85$; A-R, $n = 97$; A-P, $n = 90$.

A second set of analyses done on diagnoses of overuse injuries among the sole construction groups involved categorization of injuries by the body site involved. The sites were the knee, shank, ankle, and foot. In generating the tallies of the injuries related to a body part, a given participant was counted only once. Thus, the data compiled were the number of participants in each sole construction group diagnosed for one or more overuse injuries involving that body part. Tallies were also made of the number of participants who were diagnosed for one or more overuse injuries at any site at or below the knee. These data were the number of participants in each sole construction group who sustained at least one overuse injury to the knee, shank, ankle, or foot. For analysis, the injury counts were expressed as percentages of the number of men or women in a sole construction group. The percentages of overuse injuries by body part for the sole construction groups are presented in Table 12.

The χ^2 tests performed on the men's injury data did not reveal significant differences ($p > .05$) among sole construction groups for any of the body sites analyzed (Table 12). Examination of the women's data for each of the sites indicated that the WLT and the A-R groups had lower percentages of participants diagnosed for an overuse injury than the other two groups did and that the highest percentages were associated with the A-P group. However, a significant difference among sole construction groups was obtained only on the knee down body site category (i.e., injury to the knee, shank, ankle, or foot). The data of the female Graduates and of the female Graduates and Nongraduates combined yielded significant differences ($p < .05$ or better) among groups for this site category. The post hoc analyses done on the data for the female Graduates and for the female Graduates and Nongraduates combined revealed that the proportion of overuse injuries in the A-R group, the group with the lowest percentage of injuries from the knee down, was significantly lower than the proportion in the group with the highest percentage, the A-P group (Table 9). There were no other significant differences ($p > .05$) among the sole construction groups.

Figure 7 is a pictorial representation of the men's and the women's data for the proportions of participants with one or more overuse injuries diagnosed at or below the knee. The data in the figure are for the Graduates and Nongraduates combined.

A third approach for treating the injury data involved specific diagnoses. The more frequently occurring diagnoses are listed in Table 13 for the male and the female Graduates and Nongraduates combined. For those diagnoses made on a sufficiently large percentage of members in each sole construction group, a χ^2 test was applied, and the results are included in the table. None of the tests was significant ($p > .05$). The women's data were of particular interest here as differences in the incidences of specific types of injuries may have contributed to the differences obtained among sole construction groups when injuries were categorized by body site. From Table 13, it appears that it was not substantial differences in the incidences of one or two diagnosis categories that distinguished among the female sole construction groups, but rather relatively small differences in a number of diagnosed injuries. The men's data, as well, did not reveal differences among sole construction groups in the incidence of specific diagnoses (Table 13).

Table 12

Percentages of Men and Women in Each Sole Construction Group Diagnosed for an Overuse Injury of the Lower Extremities, Categorized by Site of the Injury, and Results of Comparative Analyses Among Groups

	Graduates[a]						Graduates + Nongraduates[b]					
Body Site	All Grps. (%)	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^c	All Grps. (%)	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^c
Men												
Knee	7.0	7.0	7.6	6.5	6.8	> .05	7.7	8.6	8.1	7.1	6.7	> .05
Shank	4.2	4.9	4.4	2.2	5.1	> .05	4.8	5.4	4.6	3.3	5.4	> .05
Ankle	3.1	2.5	3.2	3.0	3.8	> .05	3.1	2.4	3.1	3.3	3.8	> .05
Foot	2.2	1.4	1.6	2.2	3.8	> .05	2.5	2.4	1.9	2.1	3.8	> .05
Knee, Shank, Ankle, or Foot	13.0	13.0	13.1	10.9	14.8	> .05	13.9	14.8	13.6	12.1	15.0	> .05
Women												
Knee	21.7	23.4	20.5	16.3	26.9	> .05	23.4	25.9	21.2	17.5	28.9	> .05
Shank	9.3	9.3	6.4	7.6	14.1	> .05	10.8	10.3	7.0	8.2	17.8	> .05
Ankle	8.2	8.4	6.4	6.5	11.5	> .05	9.0	8.6	8.2	6.2	13.3	> .05
Foot	9.6	12.1	7.7	6.5	11.5	> .05	9.5	11.2	7.0	7.2	12.2	> .05
Knee, Shank, Ankle, or Foot	**31.3**	**36.4** **AB**	**25.6** **AB**	**22.8** **A**	**39.7** **B**	**< .05**	**34.0**	**38.8** **AB**	**27.0** **AB**	**23.7** **A**	**45.6** **B**	**< .01**

[a]Number of male Graduates in all groups combined: n = 1001. Number of male Graduates in each sole construction group: DMS, n = 284; WLT, n = 251; A-R, n = 230; A-P, n = 236. Number of female Graduates in all groups combined: n = 355. Number of female Graduates in each sole construction group: DMS, n = 107; WLT, n = 78; A-R, n = 92; A-P, n = 78.

[b]Number of male participants in all groups combined: n = 1028. Number of male participants in each sole construction group: DMS, n = 291; WLT, n = 258; A-R, n = 239; A-P, n = 240. Number of female participants in all groups combined: n = 388. Number of female participants in each sole construction group: DMS, n = 116; WLT, n = 85; A-R, n = 97; A-P, n = 90.

[c]Significance levels of χ^2 tests comparing sole construction groups. Where p < .05 or better, the relevant data are bolded, and the results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

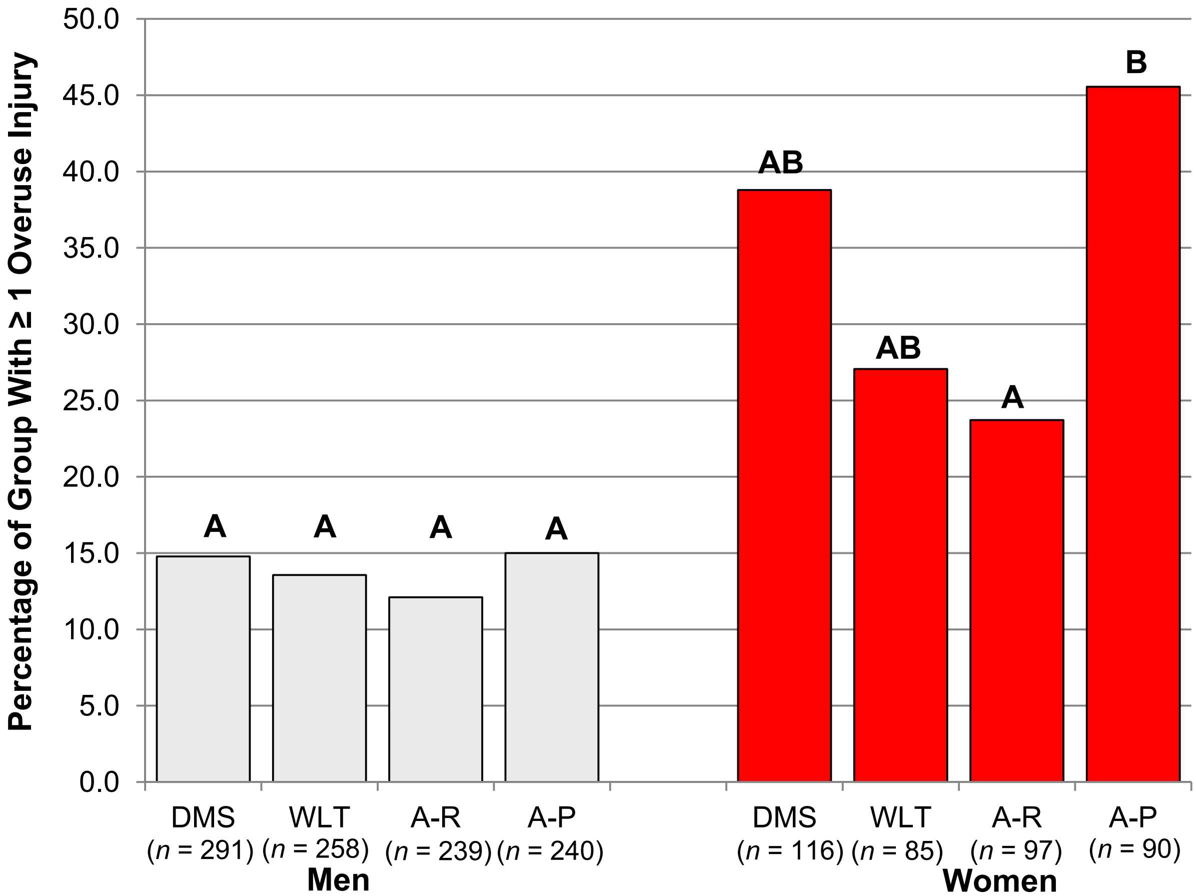

Figure 7. Percentage of each sole construction group with at least one diagnosis of overuse injury of the knee, shank, ankle, or foot. The data of both Graduates and Nongraduates are included. Within a gender, groups that do not share the same letters were significantly different at $p < .05$ or better on post hoc tests.

Trainees' Opinions of the Test Boots

Responses of participants on the questionnaire asking about experiences with the test boots during the basic training cycle (Appendix D) are presented in Table 14, along with the results of the χ^2 test applied to the responses to each question. The questionnaire, which was administered 4 to 5 days prior to the end of the training cycle, was taken by participants who were Graduates. The number of individuals taking the questionnaire was limited due to scheduling conflicts.

Table 13
Percentages of Male and Female Graduates and Nongraduates in Each Sole Construction Group Given Specific Diagnoses and Results of Comparative Analyses Among Groups

	Men[a]						Women[b]					
Diagnosis	All Grps. (%)	DMS (%)	WLT (%)	A-R (%)	A-P (%)	*p*[c]	All Grps. (%)	DMS (%)	WLT (%)	A-R (%)	A-P (%)	*p*[c]
Knee												
Localized joint pain, knee	4.9	4.8	5.8	4.6	4.2	> .05	14.7	17.2	14.1	9.3	17.8	> .05
Compression arthralgia of knee/shank	1.0	0.7	0.0	1.7	1.7		2.8	2.6	4.7	3.1	1.1	> .05
Overuse syndrome, patella	0.9	1.4	0.8	0.4	0.8		3.4	4.3	1.2	2.1	5.6	> .05
Patellofemoral pain syndrome	0.9	1.0	1.5	0.0	0.8		2.3	1.7	1.2	3.1	3.3	> .05
Patellar tendinitis	0.8	1.0	0.4	0.8	0.8		2.1	0.9	2.4	0.0	5.6	
Stress fracture, patella	0.1	0.3	0.0	0.0	0.0		0.5	0.9	0.0	0.0	1.1	
Shank												
Shin splints	1.8	1.4	2.7	1.2	2.1	> .05	4.6	5.2	2.4	4.1	6.7	> .05
Shank pain	1.9	2.1	1.9	0.8	2.5	> .05	1.8	2.6	0.0	0.0	4.4	
Overuse syndrome, shank	0.3	0.3	0.4	0.0	0.4		0.5	0.9	0.0	0.0	1.1	
Stress fracture, tibia	0.7	0.3	1.2	0.8	0.4		0.8	0.9	0.0	1.0	1.1	

Table 13 (cont'd)

Diagnosis	Men[a] All Grps. (%)	Men[a] DMS (%)	Men[a] WLT (%)	Men[a] A-R (%)	Men[a] A-P (%)	Men[a] p[c]	Women[b] All Grps. (%)	Women[b] DMS (%)	Women[b] WLT (%)	Women[b] A-R (%)	Women[b] A-P (%)	Women[b] p[c]
Ankle												
Localized joint pain, ankle	2.6	2.4	2.3	2.9	2.5	> .05	7.0	6.0	5.9	5.2	11.1	> .05
Ankle inversion sprain	2.2	2.4	3.1	0.8	2.5	> .05	4.6	6.9	3.5	1.0	6.7	> .05
Compression arthralgia of ankle/foot	0.7	0.3	0.4	0.4	1.7		2.1	2.6	0.0	1.0	4.4	
Overuse syndrome, ankle	0.1	0.0	0.4	0.0	0.0		0.5	0.0	1.2	0.0	1.1	
Tendinitis Achilles	0.4	0.7	0.0	0.0	0.8		1.3	0.9	0.0	0.0	4.4	
Foot												
Overuse syndrome, foot	1.2	0.7	1.2	0.8	2.1	> .05	1.8	2.6	2.4	0.0	2.2	
Metatarsalgia	0.3	0.0	0.4	0.8	0.0		1.8	2.6	2.4	2.1	0.0	
Plantar fasciitis	0.0	0.0	0.0	0.0	0.0		0.5	0.0	0.0	1.0	1.1	
Stress fracture, metatarsals	0.0	0.0	0.0	0.0	0.0		1.3	1.7	1.2	0.0	2.2	
Stress fracture, calcaneus	0.2	0.7	0.0	0.0	0.0		1.0	0.9	0.0	2.1	1.1	

[a]Number of male participants in all groups combined: *n* = 1028. Number of male participants in each sole construction group: DMS, *n* = 291; WLT, *n* = 258; A-R, *n* = 239; A-P, *n* = 240.
[b]Number of female participants in all groups combined: *n* = 388. Number of female participants in each sole construction group: DMS, *n* = 116; WLT, *n* = 85; A-R, *n* = 97; A-P, *n* = 90.
[c]Significance levels of χ^2 tests comparing sole construction groups.

Table 14
Responses of Male and Female Graduates in Each Sole Construction Group on the Questionnaire Administered at End of Basic Training and Results of Comparative Analyses Among Groups

		Men					Women				
Question Topic	Levels of Response	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^a	DMS (%)	WLT (%)	A-R (%)	A-P (%)	p^a
Used inserts issued with boots	Yes	25.9	20.7	14.7	21.7		17.6	15.6	6.9	17.4	
	No	74.1	79.3	85.2	78.3	> .05	82.4	84.4	93.1	82.6	> .05
	n	197	164	156	161		68	45	58	46	
Put new inserts in boots	Yes	**36.0**	**34.1**	**20.1**	**27.2**		23.5	19.6	15.2	22.2	
	No	**64.0**	**65.8**	**79.9**	**70.2**	**< .01**	76.5	80.4	84.7	77.8	> .05
		A	**A**	**B**	**AB**						
	n	200	164	159	162		68	46	59	45	
Boot soles slippery	Yes	11.6	11.0	11.5	10.5		14.7	13.3	3.4	6.5	
	No	88.4	89.0	88.5	89.5	> .05	85.3	86.7	96.6	93.4	> .05
	n	198	164	157	162		68	45	59	46	
Feet sweat too much in boots	Yes	6.5	12.7	8.2	13.7		4.3	15.2	3.3	4.3	
	No	93.5	87.3	91.8	86.3	> .05	95.6	84.8	96.7	95.6	> .05
	n	199	165	159	161		68	46	60	46	
Can feel stones and rocks through soles	Yes	**20.1**	**17.6**	**8.9**	**15.5**		20.6	15.2	18.3	8.7	
	No	**79.9**	**82.4**	**91.1**	**84.5**	**< .05**	79.4	84.8	81.7	91.3	> .05
		A	**AB**	**B**	**AB**						
	n	199	165	158	161		68	46	60	46	
Stones and mud build up in sole tread	Yes	41.0	43.0	32.7	32.7		42.6	43.5	35.0	30.4	
	No	59.0	57.0	67.3	67.3	> .05	57.4	56.5	65.0	69.6	> .05
	n	200	165	159	162		68	46	60	46	
Boots fit properly	Yes	**91.5**	**90.3**	**96.2**	**96.3**		88.2	82.6	93.3	89.1	
	No	**8.5**	**9.7**	**3.8**	**3.7**	**< .05**	11.8	17.4	6.7	10.9	> .05
		A	**A**	**B**	**B**						
	n	200	165	158	162		68	46	60	46	
Boots provide adequate ankle support	Yes	**75.0**	**85.4**	**90.6**	**89.5**		73.5	78.3	80.0	76.1	
	No	**25.0**	**14.5**	**9.4**	**10.5**	**< .001**	26.5	21.7	20.0	23.9	> .05
		A	**AB**	**B**	**B**						
	n	200	165	159	162		68	46	60	46	

Table 14 (cont'd)

Question Topic	Levels of Response	Men DMS (%)	Men WLT (%)	Men A-R (%)	Men A-P (%)	Men p[a]	Women DMS (%)	Women WLT (%)	Women A-R (%)	Women A-P (%)	Women p[a]
Boots provide adequate support in arch	Yes	79.0	80.0	83.0	87.0		57.4	67.4	73.3	71.7	
	No	21.0	20.0	17.0	13.0	> .05	42.6	32.6	26.7	28.3	> .05
	n	200	165	159	165		68	46	60	46	
Toe room sufficient	Yes	93.5	93.3	94.3	97.5		92.6	91.3	93.3	97.8	
	No	6.5	6.7	5.7	2.5	> .05	7.4	8.7	6.7	2.2	> .05
	n	200	165	159	162		68	46	60	46	
Boots rub on skin	Yes	24.2	23.9	23.6	22.4		36.8	29.5	20.3	17.4	
	No	75.8	76.1	76.4	77.6	> .05	63.2	70.4	79.7	82.6	> .05
	n	198	163	157	161		68	44	59	46	
Preferred boots	Army hot weather	69.3	67.9	78.3	77.5		74.6	73.8	82.8	78.3	
	Army temperate weather	30.6	32.1	21.6	22.5	> .05	25.4	26.2	17.2	21.7	> .05
	n	199	165	157	160		67	42	58	46	
Overall comfort of boots	Very comfortable	28.0	28.6	38.0	32.9		20.6	43.4	40.0	34.8	
	Somewhat comfortable	35.0	34.1	34.2	41.0		29.4	23.9	28.3	21.7	
	Adequate	25.0	22.6	21.5	15.5	> .05	38.2	15.2	13.3	32.6	> .05
	Somewhat uncomfortable	8.0	11.0	3.2	8.1		5.9	13.0	10.0	6.5	
	Very uncomfortable	2.5	3.6	3.2	2.5		5.9	4.3	8.3	4.3	
	n	200	164	158	161		68	46	60	46	

[a]Significance levels of χ^2 tests comparing sole construction groups. Where $p < .05$ or better, the relevant data are bolded, and results of post hoc analyses comparing sole construction groups are presented. Groups that do not share the same letter differed significantly.

There were some significant differences among sole construction groups on the end of training questionnaire, and those differences occurred in the analyses of the men's data (Table 14). Compared with the men in the A-R group, a significantly higher ($p < .05$) percentage of men in the DMS group reported that they could feel stones and rocks through the boot soles. The WLT and the A-P groups did not differ from the other two groups in responses to this question. With regard to boot fit, the proportions of men in the A-R and the A-P groups responding that their boots fit properly were significantly higher ($p < .05$) than the proportions of men in the DMS and the WLT groups reporting proper fit. In terms of ankle support, the A-R and the A-P groups had significantly higher ($p < .05$) proportions of men who indicated that the ankle support provided by the boots was adequate compared with the proportion in the DMS group. The data for the WLT did not differ significantly from the data for the other groups on this question (Table 14).

Although the women's questionnaire data did not yield significant differences ($p > .05$) among sole construction groups, there were several questions on which the groups were dissimilar in the distribution of their responses (Table 14). The question regarding whether the boots fit properly was one of these. The women's data were similar to the men's on this question to the extent that, for both genders, the lowest proportion of positive responses was given by members of the WLT group. In terms of adequacy of arch support, the majority of women in each sole construction group responded that the boots they wore were adequate in this regard. However, 73% of the women in the A-R group responded affirmatively versus 57% of the women in the DMS group. The DMS group also had the highest proportion of women who responded that their boots rubbed on the skin, 37%; the A-P group had the lowest, 17% (Table 14).

On one question, participants were asked whether they had removed the inserts that were in the test boots at the time the boots were issued. No significant differences ($p > .05$) were found among sole construction groups in responses to this question, either for the men's or for the women's data (Table 14). The vast majority of participants, 79% of all the men and 86% of all the women, responding to the question indicated that they did not use these original inserts. The reasons given most frequently were that the original inserts were uncomfortable and did not provide enough cushioning or arch support.

In a related question, participants were asked whether they had placed inserts in the test boots other than those that came in the boots. No significant differences ($p > .05$) in responses to this question were found among sole construction groups in analysis of the women's data (Table 14). For the men's data, the proportions of participants in the DMS and the WLT groups who reported putting new inserts in the boots were significantly higher ($p < .05$) than the proportion of men in the A-R group who reported using new inserts. The responses of the A-P group did not differ significantly ($p > .05$) from those of the other three groups (Table 14).

Over all sole construction groups, 30% of the men and 20% of the women responded that they put new inserts in their boots. Participants indicated that they obtained new inserts at the PX or at the Reception Station. Comparison of each participant's responses on the two questions related to insert use revealed that, of those participants who indicated that they put new inserts in their boots, 30% of the men and 40% of the women also indicated that they did not remove the

original inserts. At the time of administration of the questionnaire, the author of this report checked a number of completed questionnaires for consistency and completeness. Participants who indicated that they put new inserts in their boots but did not remove the original pair were queried about these responses. The majority of participants queried stated that their responses on the two questions were accurate — they indeed did keep the original inserts in the boots and added new ones.

On the questionnaire, participants were also queried regarding the temperate weather boots, which were issued to them approximately one week prior to administration of the questionnaire. Participants were asked whether they preferred the temperate or the hot weather boots. For both the men's and the women's data, there were no significant differences ($p > .05$) among sole construction groups in responses to this question (Table 14). Of all participants responding to the question, 27% of the men and 22% of the women indicated that they preferred the temperate weather boots. Among the reasons given was that the boots were waterproof and well cushioned. Some participants also mentioned that they like the warmth of the temperate weather boots on colder days. Of those who preferred the hot weather boots, it was frequently mentioned that the boots were lighter and cooler than the temperate boots and that the hot weather boots were well broken in, having been worn for a number of weeks of training.

The question requiring respondents to rate the overall comfort of their test boots did not yield significant differences ($p > .05$) among sole construction groups in the analysis of the men's or the women's data (Table 14). In the women's data, there was a nonsignificant trend toward more positive comfort ratings being given by members of the WLT and A-R groups, compared with members of the DMS and the A-P groups. The WLT and the A-R boots were rated as *very comfortable* by 43% and 40%, respectively, of the women in these groups, whereas the DMS and the A-P boots were rated as *very comfortable* by 21% and 35%, respectively, of the women wearing them. For the men, 38% of the members of the A-R group rated their boots as being *very comfortable*, whereas approximately 28% of the men in the DMS and the WLT groups gave a rating of *very comfortable*. A rating of *very comfortable* was given by 33% of the men in the A-P group (Table 14).

Visual Inspection of the Test Boots

The author of this report visually inspected both pairs of participants' test boots at the time of administration of the end-of-training-cycle questionnaire. Approximately 25% of the participants had worn both pairs regularly and indicated that they typically alternated between the two pairs on a daily basis. The remaining participants had used only one pair. The reason given by some trainees for doing this was that they were keeping one pair aside for wear at graduation. Others reported that it had taken them more than a week to "break in" a pair of boots (i.e., to become comfortable in the boots) and they did not want to go through the process again with the second pair.

Visual inspection of the boots that had been worn revealed very little outsole wear and no sole separation, regardless of sole construction type. Many of the boots inspected did show wear

on the upper, again regardless of type of sole on the boot. The single, most frequently occurring problem was breakage of the stitching on the foremost portion of the outside counter pocket, in the area of attachment of the counter pocket to the vamp.

DISCUSSION

Lower Extremity Injuries Among the Sole Construction Groups

For the female trainees in this study, the four sole constructions tested differentially affected dependent measures related to the cumulative incidence of overuse injuries of the lower extremities through the approximately 10 weeks of basic training. The women who wore the A-P boots during their training comprised the group with the highest proportion of individuals diagnosed for an overuse injury at or below the knee. The women who wore the A-R boots comprised the group with the lowest proportion of individuals receiving such a diagnosis. The difference between these two groups in incidences of overuse injuries was large and statistically significant. Considering the data of the female Graduates, 40% of those wearing the A-P boots were diagnosed at least once for an overuse problem at or below the knee, compared with 23% of those who used the A-R boots. When the data of the female Nongraduates were combined with the data of the female Graduates, the difference was even greater: 46% of the A-P group versus 24% of the A-R group received a diagnosis of an overuse injury at or below the knee.

The women who wore either the DMS or the WLT soling systems were between the extremes represented by the A-R and the A-P groups in terms of overuse injuries categorized by body site, and their incidences were not statistically different from those of the A-R or the A-P groups. However, at 26% for the Graduates and 27% for the combined data of the Graduates and the Nongraduates, the women comprising the WLT group were highly similar in incidences of overuse injuries to the women who wore the A-R boots. Likewise, the incidences in the DMS group, at 36% for the Graduates and 39% for the Graduates and Nongraduates combined, were closer to the incidences in the A-P group.

Some perspective on the incidences of overuse injuries among the women in the sole construction groups may be gained from data collected by Knapik et al. (2004) at Fort Jackson during 2003. Knapik and his colleagues reported that 46 to 54% of the approximately 900 women whose medical data they examined incurred at least one overuse injury during basic training. The diagnoses tallied by Knapik et al. included overuse injuries of the lower back, pelvis, and thigh, in addition to those at and below the knee. Therefore, the cumulative incidences obtained in the current study should be somewhat lower than those found by Knapik et al. That is, indeed, the case, except for the injury incidences in the A-P group, which approached the levels reported by Knapik and his colleagues.

As was found for the overuse diagnoses categorized by body site of the injury, the data on the women's sick call attendance for a lower extremity complaint revealed differences among sole construction groups that were large and statistically significant. The A-R group had the lowest proportion of individuals who attended sick call one or more times for a lower extremity complaint, followed by the WLT group. Considering only the female Graduates, 26% of the A-R group and 31% of the WLT group made at least one sick call visit for a lower extremity complaint. This contrasts with 47% of the Graduates in the A-P and 49% of the Graduates in the DMS groups attending one or more sick calls. In the statistical analyses of the Graduates' data, the A-R group was found to differ significantly from both the A-P and the DMS groups, whereas the WLT group did not differ significantly from the other three.

For the combined data of the female Graduates and Nongraduates, the A-P group, at 52%, had the highest proportion of women who attended at least one sick call, followed closely by the DMS group, at 51%. The A-R group was again lowest, with 27% of the female Graduates and Nongraduates attending at least once; the WLT group followed, with 32% attending one or more sick calls. The statistical analyses of the combined data of the female Graduates and Nongraduates with one or more sick calls revealed that the A-R group differed significantly from the A-P and the DMS groups, which did not differ from each other. In addition, the WLT group was significantly different from the A-P group, but not from the A-R or the DMS groups.

The data on the proportions of women whose regular training activities were curtailed for at least one day for recuperation from a lower extremity overuse injury were similar to the data for the diagnoses categorized by body site and for sick call attendance in again revealing a distinction between the A-P and the DMS groups relative to the A-R and the WLT. The A-P group was the sole construction group having the highest proportion of women placed on restricted duty for one or more days, at 35% and 41% for the Graduates and the Graduates plus the Nongraduates, respectively. The A-P group was followed by the DMS. The WLT group had the lowest proportion of women placed on restricted duty for a least one day, at 20% for the Graduates and 21% for the Graduates plus Nongraduates. The proportions for the A-R group were only slightly higher than those for the WLT. Although this ordering of sole construction groups was the same for the data of the female Graduates and the female Graduates plus Nongraduates, a statistically significant effect of sole construction was obtained only for the combined data of the Graduates and Nongraduates. The A-P group, the group with the highest proportion of women having one or more days of restricted duty, differed significantly from the WLT group, the group with the lowest proportion of women with a duty restriction. The DMS and the A-R groups did not differ significantly from each other or from the WLT and the A-P groups.

Given the findings regarding the differences among the women's sole construction groups in overuse diagnoses categorized by body site, in sick call attendance, and in restriction of activities for a period of recuperation, higher incidences of one or more specific lower extremity injuries would be expected for the A-P and the DMS groups than for the A-R and the WLT groups. This was not found: Examination of the women's lower extremity disorders did not reveal diagnoses that were unique to or most characteristic of a particular sole construction. There were a number of diagnoses for which the A-P or the DMS construction was associated with somewhat higher incidences than the A-R or the WLT. Knee joint pain, shin splints, and ankle inversion sprains are examples of this. However, the differences among sole construction groups in the occurrences of particular diagnoses were small and not statistically significant. Thus, it appears that the significant findings in diagnoses of injuries at and below the knee, sick call attendance, and restricted duty were attributable to modest differences among the groups in the incidences of a number of the overuse injuries diagnosed among the women, rather than to large differences in the incidences of one or two particular disorders.

Unlike the women's data, the men's data did not yield statistically significant differences among sole construction groups for dependent measures related to the cumulative incidence of overuse problems of the lower extremities. In terms of injuries sustained at or below the knee, the proportion of men diagnosed for an overuse problem was lower in the A-R group than in the

other three sole construction groups. The A-R group also had the lowest proportion of men attending sick call on one or more occasions and the lowest proportion receiving at least one day of restricted duty for a lower extremity problem. However, the differences among the groups in these dependent measures were small. As was the case for the women, analyses of the men's data for specific diagnoses did not reveal injuries that occurred significantly more frequently in one sole construction group than another.

Although neither the men's nor the women's sole construction groups differed in the types of lower extremity disorders diagnosed, it is possible that there were differences among the groups in the severity of the injuries sustained. The number of sick calls an individual attended and the number of days an individual spent on restricted duty would be expected to be indicators of severity of the problem diagnosed. Analyses of the average number of sick call visits made and the average number of days spent on restricted duty status did not reveal differences among the groups for the men or for the women. Further, excluding medical conditions deemed to have existed prior to entrance into the Army, only two (0.2%) of the 1,028 male participants in the study and three (0.8%) of the 388 female participants failed to graduate from training because of a lower extremity problem. If attrition from training or the numbers of sick call visits and days of restricted duty are indications of the severity of disorders, then the disorders incurred by individuals in one sole construction group were no more severe than those sustained by individuals in the other groups.

The dependent measures of attrition from training, overuse injuries diagnosed, sick call attendance, and duty restrictions are related to the cumulative incidence of lower extremity injuries over the basic training cycle; they do not involve the time dimension. However, the person-days analysis that was carried out to compare the injury incidence rates of the sole construction groups was time-based, entailing calculation of time to first overuse injury. Time to first overuse injury was taken as the training day on which an individual was diagnosed for an overuse injury at or below the knee and was placed on restricted duty for the first time to recuperate. If an individual graduated basic training without having received any days of restricted training, total training time was set at 65 days. For Nongraduates, total time in training was calculated to the day they ceased training.

The women's injury incidence rates, expressed as injuries per 1,000 female trainees per day of training, ranged from a low of 4.15 for the WLT group to a high of 8.18 for the A-P group. Analyses comparing the sole construction groups yielded a statistically significant difference between these two groups, a finding in line with the results for the overuse diagnoses categorized by body site, the sick call visits, and the restriction of training for recuperation. Thus, this time-based measure, like the measures reflecting cumulative incidence of lower extremity injuries over the basic training cycle, provided evidence that the women in the A-P group were at a disadvantage relative to those in the WLT group in terms of risk of lower extremity injuries.

It appears that, prior to this study, the most recent data on overuse injuries occurring among trainees at Fort Jackson were acquired in 2007 by Knapik et al. (2009). Data on overuse injuries incurred throughout the approximately 10 weeks of basic training were obtained at that time for about 1,300 women. Injury incidence rates were calculated and were reported as 8.6 to

8.8 injuries per 1,000 female trainees per day. Knapik et al. tracked occurrences of injuries to the lower back, pelvis, and thigh, as well as those diagnosed at and below the knee. Further, they defined time to first injury as the training day on which an individual attended sick call for a lower extremity problem for the first time; they did not include in their definition the requirement that the individual be put on restricted duty. Given the smaller number of body sites included in the data and the more stringent definition of time to first injury in the current study, injury rates here would be expected to be lower than those reported by Knapik et al. The injury rates for the DMS, WLT, and A-R groups were lower than those for the women in the Knapik et al. study, but the A-P group had an injury rate that approached those found by Knapik et al.

Unlike the women's data, the men's injury incidence rates, expressed as injuries per 1,000 person-days, were similar for the four sole construction groups, ranging from 1.28 to 1.80 injuries per 1,000 male trainees per day. The lowest value was for the A-R group and the highest value for the WLT. As was found for the men's data on the measures involving diagnoses of injuries at or below the knee, sick call visits, and restriction of training for recuperation, analysis of the men's injury incidence rates did not yield statistically significant differences among the sole constructions.

The finding that the dependent measures related to overuse injuries among the women revealed substantially higher morbidity in the A-P and the DMS sole construction groups relative to those in the A-R and the WLT groups raises the issue of whether the results were due to differences in the boot constructions or to unintended bias in assignment of group membership. Assignment of individuals to sole construction groups was random, but there is the possibility that the A-P and the DMS groups included larger proportions of women with risk factors for overuse injuries than the two other groups.

Comparisons among the women's sole construction groups for age and physical characteristics did not yield any significant findings, and the differences were small. The questionnaire administered at the time of study initiation to obtain participants' demographics and information related to risk factors for injuries also failed to yield any significant differences among the women's sole construction groups, although there were some small differences. The differences included smoking habits, physical activity levels, and frequency of regular exercise. On these factors, there were no consistent findings indicating lower occurrences of risk factors for injuries in one sole construction group relative to the others. Another difference was the distribution of the women with regard to service component: The A-P and the DMS groups had higher proportions of National Guard personnel than the A-R and the WLT, which had higher proportions of Regular Army personnel. A past study in which service component was examined as a risk factor for injuries among Army trainees found no effect (Knapik et al., 1999), but a second study reported lower injury rates for National Guard than for Regular Army trainees (Knapik et al., 2009).

To investigate the implications of service component in the current study, the women's injury diagnoses categorized by body site were reanalyzed for this variable. No differences were obtained: About 32% of the women in the Regular Army and the same percentage of women in the National Guard were diagnosed for at least one overuse injury at or below the knee. The men's data also were reanalyzed by service component. Again, no significant difference was

found: 15% of the men in the Regular Army and 11% of the men in the National Guard were diagnosed for an overuse injury at or below the knee. Considering the composition of the women's sole construction groups, as well as the men's, there was no apparent bias toward any one of the groups being consistently different from the others in areas likely to affect the risk of incurring lower extremity disorders.

Subjective Responses of the Sole Construction Groups

The dependent variables related to overuse injuries of the lower extremities yielded consistent results indicating that boots in the A-R and the WLT constructions are preferable to boots in the A-P and the DMS constructions for wear by Army women. Unlike the women's data, the men's injury data did not reveal statistically significant effects, although the small differences that were found favored the A-R construction. There were statistically significant differences, however, among the men's sole construction groups on the questionnaire administered at the end of the training cycle.

The questionnaire included two questions on the removable inserts that were furnished in all test boots and that are also currently issued in Army combat boots. Removing the inserts and purchasing a commercial brand to replace them is the most direct way a user has to try to improve comfort, foot support, or footwear fit. It may be posited that replacement of the original inserts is an indicator of users' generalized dissatisfaction with aspects of their boots. The men's questionnaire responses revealed that a significantly greater proportion of members of the DMS and the WLT groups put new inserts in their boots, compared with members of the A-R group. Further, relative to the other groups, a lower proportion of men in the A-R group reported that they had left the original inserts in their boots, although the difference among sole construction groups was not significant. There were no statistically significant findings in the women's data for the questions regarding the removable inserts, but their responses paralleled the men's. That is, a lower proportion of the A-R group reported putting new inserts in their boots compared with the other groups, and a higher proportion of the A-R group reported removing the original inserts.

Over all sole construction groups, approximately 30% of the men and 40% of the women indicated that they added a new pair of inserts without removing the original pair. The author asked some participants why they did this and was told it was done to increase cushioning. The apparent goal was to have as much cushioning material as possible between the foot and the ground.

A question on adequacy of boot fit was included in the end-of-training questionnaire. Army trainees typically have little exposure to wearing boots prior to beginning basic training, and that was the case with the participants in this study. In the questionnaire administered at study initiation, participants were asked what type of footwear they had worn most often over the past year. Approximately 6% of the men and 2.5% or less of the women reported wearing boots regularly during that period. Given the participants' limited experiences with wearing boots and the fact that they had used only one type of boot during most of their time in basic training, posing a question regarding adequacy of boot fit was not expected to draw well informed opinions, such as one would expect from permanent party Army personnel. Rather, the question

was included as a means to again obtain users' opinions that were likely to be reflective of generalized satisfaction or dissatisfaction with the footwear. In responses to the question on fit, significant differences were obtained among the men's sole construction groups. There were higher proportions of responses affirming that the boots fit properly in the A-R and the A-P groups than in the DMS and the WLT groups.

Questions on elements of boot functional adequacy also elicited responses that differentiated among the men's sole construction groups. There were significantly higher proportions of men who reported that their boots provided adequate ankle support in the A-R and the A-P groups than in the DMS group. The men's responses to a question regarding feeling stones and rocks through the soles of their boots again differentiated among groups, with the proportion of the A-R group who answered in the affirmative being significantly lower than the proportion in the DMS group.

There were no statistically significant differences among women's sole construction groups on the questionnaire administered at the end of basic training, but there were several questions on which the responses of the groups were dissimilar. The proportion of the WLT group reporting that their boots fit properly was relatively low, compared with the responses of the other groups. The A-R group was highest and the DMS group lowest in the proportions of women who affirmed that the arch support provided by the boots was adequate. The DMS group also received the highest proportion of responses indicating that the boots rubbed the skin.

Participants were asked in one question to rate their opinions of the overall comfort of their combat boots. Given the participants' limited experience with combat boots, this question, like some of the others, was included to elicit indicators of participants' generalized satisfaction or dissatisfaction with the boots, as opposed to the informed opinions one would expect from experienced military personnel.

The women's ratings of overall comfort of their boots favored the A-R and the WLT. The A-R and the WLT groups, which were also associated with lower incidences of overuse injuries, gave higher proportions of *very comfortable* ratings than the other two groups, and the DMS group was lowest in the proportion of *very comfortable* ratings. The responses of the men's sole construction groups on the question regarding boot comfort were reflective of the responses on other questions. That is, the A-R group had more favorable opinions of their boots when contrasted with the opinions of the other sole construction groups. Thus, for the men, the highest proportion of *very comfortable* ratings was given by the A-R group, whereas the DMS and the WLT groups gave the lowest proportions of *very comfortable* ratings.

Sole Constructions for Combat Boots

Given the substantial differential effects that the sole constructions had on dependent variables related to women's overuse injuries, the findings from the current study indicate that combat boots in the A-R and the WLT constructions are preferable to boots in the A-P and the DMS constructions for wear by Army women. With regard to the men's data, there was an indication of a lower incidence of injuries with the A-R construction, albeit the finding was not statistically significant, and the men's opinions of their boots after approximately 10 weeks of

use provided some basis to support introduction of both the A-R and the A-P constructions into Army combat boots. Unlike the women's data, however, the men's data did not reveal definitive evidence of differences in injury risk with the different sole constructions.

One possible reason that injury outcomes for the women differentiated among sole constructions and the outcomes for the men did not differentiate among constructions is the fit of the combat boots in the different sole constructions. By using the foot length and breadth measurements taken with the Brannock Foot Measuring Device as a baseline and contrasting the boot sizes actually issued against the baseline, some indication was obtained of differences in fit between the men and the women using boots made in the same sole construction. Regarding the relationship between predicted and issued lengths, a higher proportion of women than men in the A-R group received a length shorter than was predicted. For the A-P group, a lower proportion of women than men were issued a shorter length. There were differences, as well, between predicted and issued boot widths for the men and women in the DMS and the A-R groups. The data do not permit conclusions to be made regarding whether the boots provided a better or a poorer fit for the men than for the women. However, these findings do indicate differences between the men and the women in the fit of boots in the various sole constructions.

Another possible reason that injury outcomes for the men did not differentiate among sole constructions like the outcomes for the women did may lie in women's higher risk for overuse injuries of the lower extremities, a well-established finding for both military and civilian segments of the population (Bensel & Kish, 1983; Knapik et al., 1999; Knapik et al., 2009; Kowal, 1980; Milner, Ferber, Pollard, Hamill, & Davis, 2006; Reinking, 2006; Subcommittee on Body Composition, Nutrition, and Health of Military Women, 1998). The women, with their lower threshold for incurring injuries, may have been affected by differences among the sole constructions that were not of sufficient magnitude to impact the likelihood of injuries among the men.

Results obtained for the WLT construction provide some support for this postulation. Hamill's testing (Appendix A) of the mechanical properties of the four sole constructions included in the current study indicated that the WLT had the best shock attenuation. As measured on the impact test, the WLT had the lowest peak g, the longest time to peak g, and the lowest force values. The DMS was at the other extreme, having the highest peak g, the shortest time to peak g, and the highest force values. Good shock attenuation is a footwear characteristic thought to be beneficial in minimizing overuse injuries (Clarke, Frederick, & Cooper, 1983; Hamill & Bensel, 1992, 1996; James, Bates, & Osternig, 1978). A finding from the current study compatible with this is that the WLT construction, along with the A-R, was associated with lower incidences of overuse injuries for the women, relative to the DMS and the A-P constructions. The men's injury data, on the other hand, did not indicate a benefit from using the WLT construction or a detriment from using the DMS, and the men's opinions about the boots that were elicited on the end-of-training questionnaire tended to be more positive in the A-R and in the A-P groups than in the DMS and the WLT groups.

In reporting on his testing of the mechanical properties of the four constructions, Hamill (Appendix A) concluded that the DMS exhibited the qualities most desirable in a military boot. The conclusion was based on the findings that the DMS had the lowest stiffness values and that

its midfoot torsion values were not extreme. Further, although the impact properties of the DMS were poorer than those of the other constructions, results for the DMS construction on the impact test did not differ greatly from those for the other three constructions. The men's injury data provided no strong evidence to suggest that one of the other sole constructions is preferable to the DMS. The women's injury data favored the A-R and the WLT constructions over the DMS. Hamill's testing indicated that the A-R was somewhat better than the DMS in terms of impact characteristics and that the WLT had the best shock attenuation. The A-R and the WLT also had stiffness and torsion characteristics that were not greatly different than those of the DMS. The A-P, which, along with the DMS was associated with higher incidences of women's overuse injuries, exhibited greater resistance to rotation in pronation than the other sole constructions. It is not known whether this characteristic of the A-P construction contributed to the women's injuries.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings for the dependent variables related to overuse injuries among the women in the current study, there is evidence that an injection-molded, direct-attach construction with a polyurethane outsole, represented in the study by the A-P test boot, should not be added to the three-layer soling systems authorized for Army combat boots. However, production of boots in a direct-attach construction with a rubber outsole, represented by the A-R test boot, is acceptable from the perspective of lower extremity health and user acceptance. Further, the women's injury data indicate that Army women who are presently wearing boots in the currently authorized direct-molded sole construction, represented in the study by the DMS test boot, may be experiencing more overuse injuries than those women wearing boots in a welt construction, which is also a currently authorized soling system. The men's injury data, unlike the women's, revealed only small, nonsignificant differences among the sole constructions investigated in the study. The small differences that were found favored the A-R test boot. In terms of opinions about the boots, the men who wore the A-R boot tended to have more favorable opinions about their boots than the men using the other sole constructions.

The following recommendations are made based on the findings from this study:

- An injection-molded, direct-attach construction with a polyurethane outsole should not be considered further as a soling system for Army boots.

- If an injection-molded soling system is going to be authorized for production of Army boots, the A-R boot tested in the current study is a good choice from the perspective of lower extremity health and user acceptance.

- There is no basis from the present study to recommend that either of the two currently authorized soling systems, a welt and a direct-molded sole construction, be deleted from the Army boot specification. However, there is the possibility that women would experience fewer overuse injuries by wearing boots in a welt construction rather than in a direct-molded sole construction.

- Breakage of stitching on the uppers was noted during visual inspections of the study boots after they had been worn for approximately 10 weeks of basic training. Approaches for remedying this problem should be explored.

This document reports research undertaken at the U.S. Army Natick Soldier Research, Development and Engineering Center, Natick, MA, and has been assigned No. NATICK/TR- 13/030 in a series of reports approved for publication.

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APPENDIX A

Testing of the Mechanical Properties of Four Soling Constructions for Combat Boots

Professor Joseph Hamill, Ph.D.
Department of Kinesiology
University of Massachusetts
Amherst, MA 01003

Prepared under NSRDEC Contract No. W911QY-08-P-0707

Introduction

The purpose of this effort was to mechanically test specific Army footwear. The mechanical tests conducted were: 1) impact test on the forefoot and the rearfoot; 2) forefoot flexibility; and 3) midfoot torsion. There were seven pairs of each of four types of footwear available for testing. The four types were identical, except for the soling system. The uppers of all types were the uppers used in the current Army hot weather boots. The four soling systems were:

- DMS — Three-layer direct-molded sole construction, manufactured by McRae Industries, Incorporated (Mount Gilead, NC, USA)
- WLT — Three-layer welt sole construction, manufactured by McRae Industries, Incorporated
- A-R — Injection-molded midsole construction directly attached to a solid rubber outsole, manufactured by Belleville Shoe Manufacturing Company (Belleville, IL, USA)
- A-P — Injection-molded midsole construction directly attached to a polyurethane outsole, manufactured by Belleville Shoe Manufacturing Company

Method

All testing was conducted in the Biomechanics Laboratory at the University of Massachusetts-Amherst. Because it was necessary to remove the upper for the impact test, the footwear was initially tested for forefoot flexion and midfoot torsion. The upper was then removed and impact testing ensued. The right and the left members of seven pairs of each footwear type were tested. All footwear was tested in an unworn state.

Impact Test

An Exeter Research Impact Tester (Exeter Research, Brentwood, NH, USA) was used to assess impact and rebound. This instrument is designed to test footwear according to an ASTM standard (ASTM F 1976, 2006). It consists of a metal shaft, or missile, that slides freely in the vertical plane. The missile head attached to the metal shaft is a solid, metal cylinder, 10.2 cm long with a diameter of 4.5 cm. The shaft and the missile head have a combined mass of 3 kg. Another mass is added to the top of the shaft to obtain a drop mass of 8 kg. The drop height of

the missile is set at 5 cm. The footwear being tested is held in place below the shaft by a clamp. The impact test instrument is computer interfaced and samples at 1000 Hz via an analogue to digital (A/D) converter. The computer controls the missile drop height and the number of impacts, or drops. A linear variable differential transducer (LVDT) and a Kistler (Novi, MI, USA) accelerometer return the data on each drop of the missile to the computer via the A/D converter. In the context of the human/footwear system, the impact tester is intended to mimic the foot hitting the ground at foot strike.

Four measurements are made during impact testing. They include peak g and time to peak g, which are illustrated in Figure A-1. Peak g, which is expressed in multiples of acceleration due to gravity, is the maximum acceleration of the missile head upon impacting the shoe. In terms of the human/footwear system, peak g is used as an index of the vertical impact force occurring at initial contact of the foot with the ground during running. As measured on the impact test, peak g is interpreted as an indicator of the shock-attenuating properties of the shoe, with lower values indicating better shock absorbency (ASTM F 1976, 2006; Cavanagh, 1980). Time to peak g, which is expressed in ms, is the time from first contact of the missile head with the shoe to achievement of maximum deceleration. Longer times to peak g on the impact test are interpreted as indicators of better cushioning in the shoe (Cavanagh, 1980).

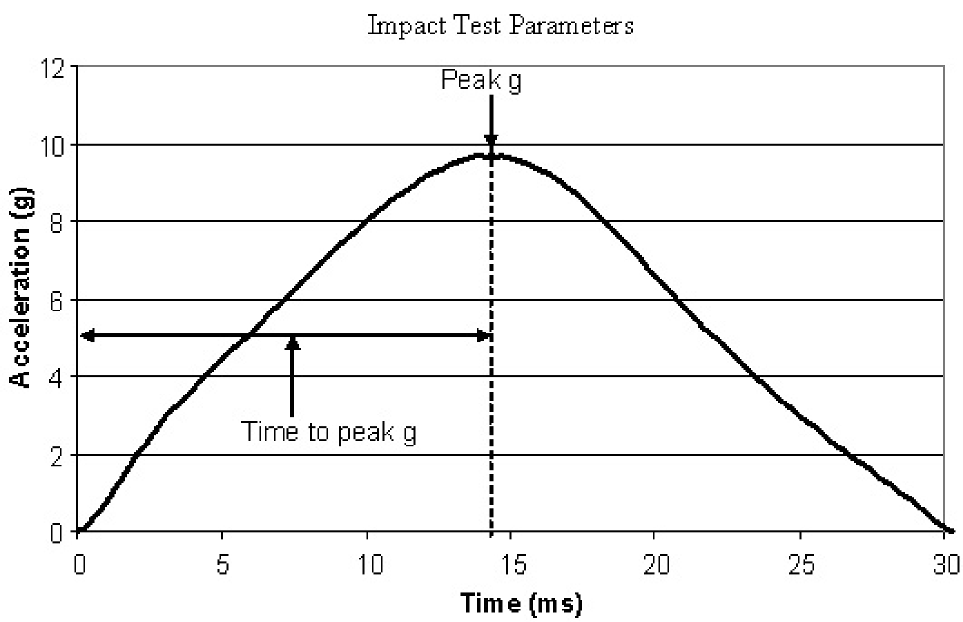

Figure A-1. Illustration of impact test parameters, peak g and time to peak g.

The other two parameters measured on the impact test are force and energy return. Force, expressed in N, is the force exerted on the shoe by the missile head at the time of maximum acceleration. As is the case for peak g, lower values of force are interpreted as indicating better shock absorbency. Energy return, in percentage, is the coefficient of restitution multiplied by 100. The energy return parameter emphasizes the fact that 100% of the kinetic energy is conserved in a perfectly elastic impact and 0% of the energy is conserved in a completely inelastic impact (Hamill & Bensel, 1992). Higher energy return values are taken as indicators of better cushioning in the shoe.

To acquire the impact data for this study, the rearfoot, or heel area, and the forefoot of each sample were subjected to 25 preliminary impacts, immediately followed by 10 test impacts. Data were recorded during each of the test impacts, but not during the preliminary impacts. For each of the four parameters, a mean was calculated over the data for the 10 test impacts on the forefoot. Likewise, a mean was calculated over the 10 test impacts on the rearfoot. The thickness of the sole can affect impact test results. Therefore, thickness measurements were also made on the forefoot and the rearfoot areas of each footwear sample.

Flexibility Test

This test was carried out on a specially designed flexion machine, modeled after that used by Cavanagh (1978). The footwear was intact for this test. The flexion device has two platforms connected by a hinge. One platform is fixed and the other is movable. The middle and the rear parts of the shoe are clamped to the movable platform; the forepart is mounted on the fixed platform. The forepart is secured to the platform by inserting a flat, metal plate in the forefoot and using a clamp with a load of 136 kg to press down on the metal plate. The shoe is positioned relative to the two platforms such that a line across the shoe from the fifth to the first metatarsal is aligned with the hinge between the platforms. During the test, flexion occurs at the part of the shoe aligned with the hinge. This site is selected because high-speed films of humans running in running shoes have shown that the maximum flexion of the shoe occurs across this portion of the shoe.

A load cell is mounted on the device to measure the force of the resistance of the forepart of the shoe to movement of the movable platform. Motion of the platform is accomplished by a torque motor. The motor displaces the movable platform at a set rate from 0° through 43°. The maximum displacement is comparable to the maximum achieved during human locomotion. A potentiometer is mounted to the hinge between the two platforms in order to measure angular displacement. Because shoes commonly have a natural flexion at the forefoot of about 10° and must be stretched to achieve a flexion of 0°, torque measures are taken only during the period of flexion from 10° to 43°. The output of the load cell is proportional to the instantaneous force applied by the motor to displace the movable platform. The output of the cell is fed to a microcomputer which performs on-line calculations of the torque required to produce the change in angle. This is expressed in $N \cdot m \cdot degree^{-1}$.

For this study, a sample was subjected to 50 preliminary flexes, followed by a test period of 30 flexes. This was followed by a further 2,000 flexes and a test period of 30 flexes. Following 5 min in which there was no flexion of the footwear, another test period of 30 flexes was accomplished. The total number of flexes approximates the number of times, on average, that a shoe is flexed over the course of a 5-mi run. A mean stiffness value was obtained over the 30 flexes making up a test period.

Exemplar data from the flexibility test are presented in Figure A-2. Lower values on the test are interpreted as indicating lower forces required to bend the forefoot of the footwear and, thus, better flexibility in the footwear (Hamill & Bensel, 1992). In terms of the human/footwear system, the less flexible the footwear, the more force the muscles of the foot and leg must apply

to bend the shoe in order to propel the body forward into the next step. Therefore, the less flexible the forefoot of the shoe, the more the muscles may be stressed (Cavanagh, 1980).

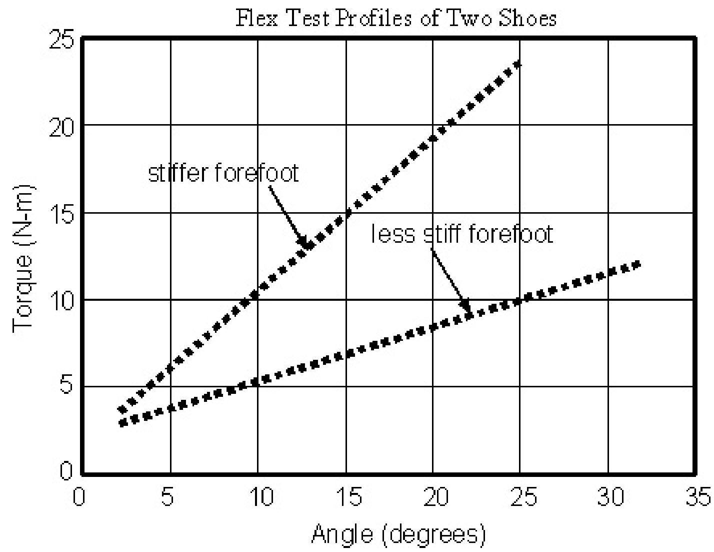

Figure A-2. Exemplar data for shoe forefoot stiffness obtained from the flexibility test.

Torsion Test

This test was performed on the midfoot area of the footwear to determine the stiffness of the midfoot as the rearfoot and the forefoot were twisted along the long axis of the shoe. The footwear was intact for this testing. The device used consists of two platforms. One platform is fixed and the other is movable. The shoe is placed on the platforms such that the forefoot area lies on the movable platform and the rest of the shoe lies on the fixed platform. The shoe is held in place by two clamps that exert a force of 136 kg on the rearfoot and the forefoot portions of the shoe. The movable platform is displaced through a range of 25° by a crank attached to a torque motor. The movement twists the sole along the long axis of the shoe in both a pronation and a supination direction. A load cell measures force necessary to displace the movable platform; a potentiometer, located at the moveable platform, measures the angular distance moved.

The voltage outputs from the load cell and the potentiometer are routed through an A/D converter interfaced to a microcomputer. The voltage outputs are then converted to N·m of torque and degrees of angular displacement. The dependent measure, stiffness, is calculated as the slope of the torque-angular displacement curve over the 25° range. Stiffness is expressed in $N \cdot m \cdot degree^{-1}$. A lower stiffness value indicates a more compliant shoe.

The data for this study were acquired by subjecting a footwear sample to 30 successive trials. A mean was obtained over the trials on each border to represent the stiffness of the sample.

Statistical Analysis

A Cohen's Effect Size (ES) calculation (Cohen, 1991) was used to detect meaningful differences among footwear types. For this calculation, an ES > 0.8 was considered a large effect, an ES > 0.5 a moderate effect, and ES < 0.2 a small effect.

Results

The means of the sole thickness measurements made on the right and the left members of seven pairs of a footwear type are presented in Table A-1. The mean values of all impact test parameters for each sole construction type are presented in Table A-2. The means were again calculated over the right and the left members of seven pairs of a footwear type. The peak acceleration and the time to peak acceleration data are presented graphically in Figures A-3 and A-4, respectively.

Table A-1
Means of Sole Thickness Measurements (in mm) Made on Each Sole Construction Type

Sole Construction Type	Forefoot Thickness	Rearfoot Thickness
DMS	25.96	49.79
WLT	25.66	48.77
A-R	20.93	42.47
A-P	23.38	47.79

Note. Means were calculated over measurements made on the right and the left members of seven pairs of boots in each sole construction type.

The right and the left members of seven pairs of each sole construction type were subjected to the flexibility and the torsion testing. The mean values obtained on the flexibility test are in Table A-3. Maximum torque, in N·m, and angle at maximum torque, in degrees, are presented in the table, along with the stiffness values, which are expressed in N·m·degree^{-1}. These data are presented for each of the test periods. The mean stiffness values are presented graphically in Figure A-5. The torsion data for both supination and pronation are in Table A-4. These data are also presented graphically in Figure A-6.

Table A-2
Means (SD) of Impact Test Values for Each Sole Construction Type

Sole Construction Type	Peak g (multiples of acceleration due to gravity)	Time to Peak g (ms)	Force (N)	Energy Return (%)
		Forefoot		
DMS	16.91 (0.15)	4.64 (0.12)	1408.70 (4.10)	48.85 (1.05)
WLT	14.00 (0.15)	6.87 (0.14)	1167.26 (3.97)	52.11 (1.06)
A-R	16.29 (0.14)	5.37 (0.13)	1357.99 (3.04)	55.30 (0.81)
A-P	15.03 (0.16)	6.20 (0.12)	1252.43 (13.13)	60.31 (0.79)
		Rearfoot		
DMS	13.29 (0.14)	7.34 (0.13)	1107.44 (3.21)	54.59 (0.97)
WLT	11.64 (0.13)	8.81 (0.12)	970.08 (2.50)	54.87 (0.81)
A-R	12.06 (0.13)	6.30 (0.10)	1005.32 (2.57)	61.17 (1.32)
A-P	12.24 (0.15)	6.22 (0.13)	1007.45 (4.22)	55.64 (0.56)

Note. Means were calculated over measurements made on the right and the left members of seven pairs of boots in each sole construction type.

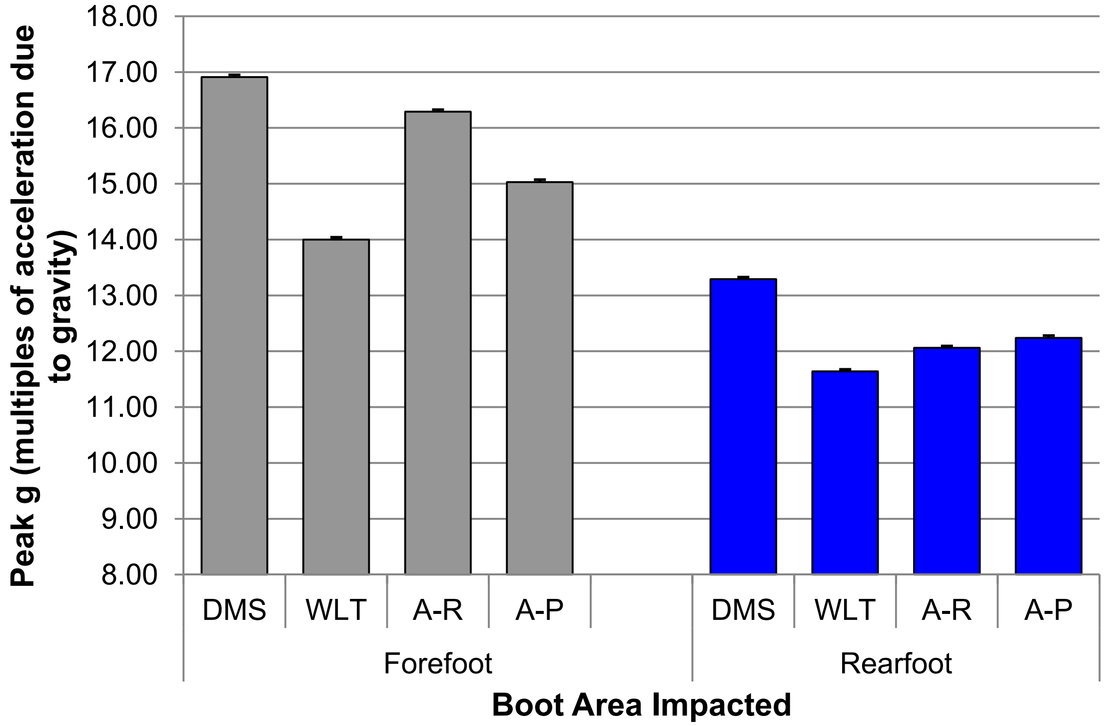

Figure A-3. Mean (*SEM*) peak g values in the forefoot and the rearfoot areas obtained for each sole construction type on the impact test.

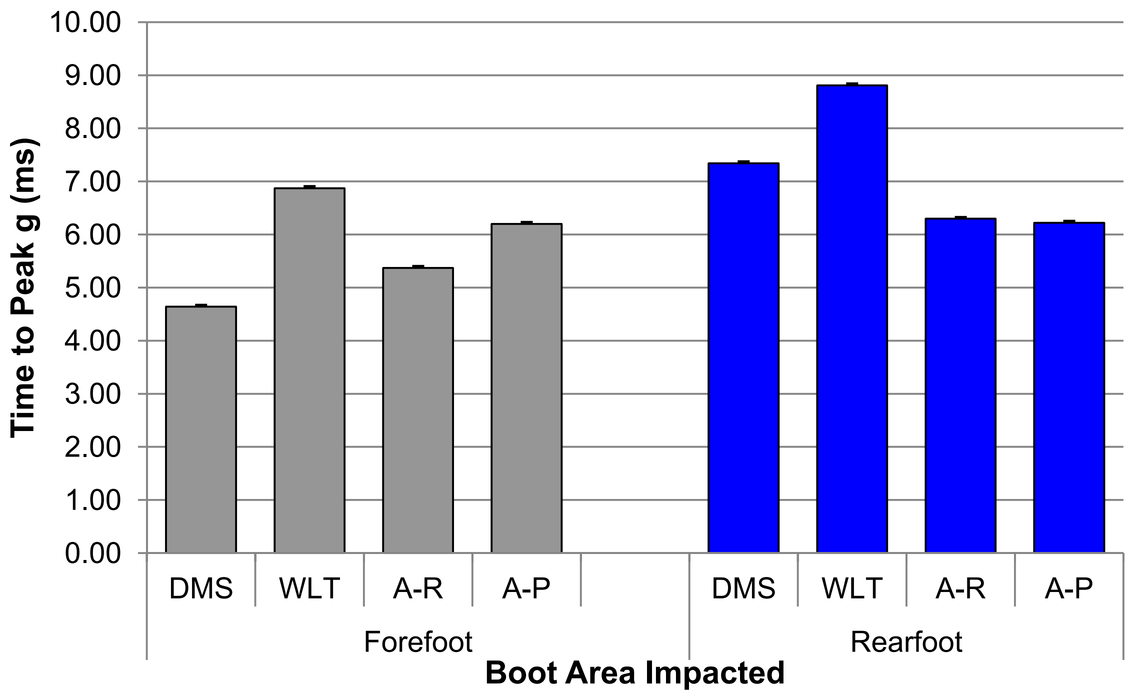

Figure A-4. Mean (*SEM*) time to peak g values in the forefoot and the rearfoot areas obtained for each sole construction type on the impact test.

Table A-3
Means (SD) of Flexibility Test Values for Each Sole Construction Type

Sole Construction Type	Stiffness (N·m·degree^{-1})	Max. Torque (N·m)	Angle at Max. Torque (degrees)
	After 50 Flexes		
DMS	0.553 (0.050)	47.30 (6.26)	43.58 (11.21)
WLT	0.588 (0.060)	46.16 (7.72)	46.15 (1.96)
A-R	0.726 (0.150)	46.67 (7.67)	44.72 (4.63)
A-P	0.657 (0.150)	47.96 (8.68)	20.48 (1.58)
	After 2,000 Flexes		
DMS	0.474 (0.050)	45.25 (4.49)	46.80 (1.07)
WLT	0.538 (0.070)	44.51 (5.79)	46.71 (1.44)
A-R	0.604 (0.070)	46.30 (3.56)	45.95 (1.79)
A-P	0.607 (0.120)	46.84 (6.14)	46.21 (1.28)
	After 5-min Rest		
DMS	0.497 (0.060)	46.70 (4.84)	37.90 (12.42)
WLT	0.575 (0.070)	46.12 (6.78)	46.57 (1.44)
A-R	0.629 (0.070)	47.80 (3.91)	23.76 (1.50)
A-P	0.630 (0.120)	47.02 (7.69)	45.73 (2.02)

Note. Means were calculated over measurements made on the right and the left members of seven pairs of boots in each sole construction type.

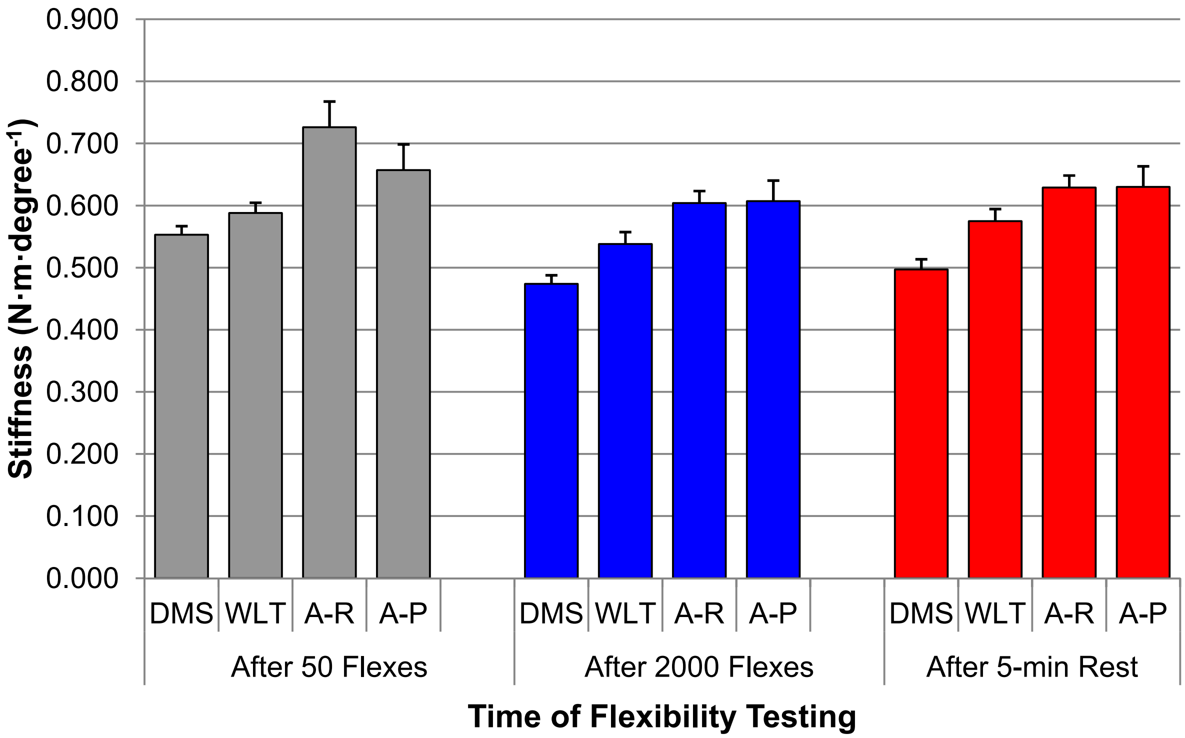

Figure A-5. Mean (*SEM*) stiffness values for the three test periods obtained for each sole construction type on the flexibility test.

Table A-4

Means (SD) of Torsion Test Values (in N·m·degree^{-1}) for Each Sole Construction Type

Sole Construction Type	Pronation	Supination
DMS	1.005 (0.007)	0.941 (0.002)
WLT	1.005 (0.007)	0.943 (0.009)
A-R	1.003 (0.007)	0.943 (0.006)
A-P	1.023 (0.009)	0.941 (0.007)

Note. Means were calculated over measurements made on the right and the left members of seven pairs of boots in each sole construction type.

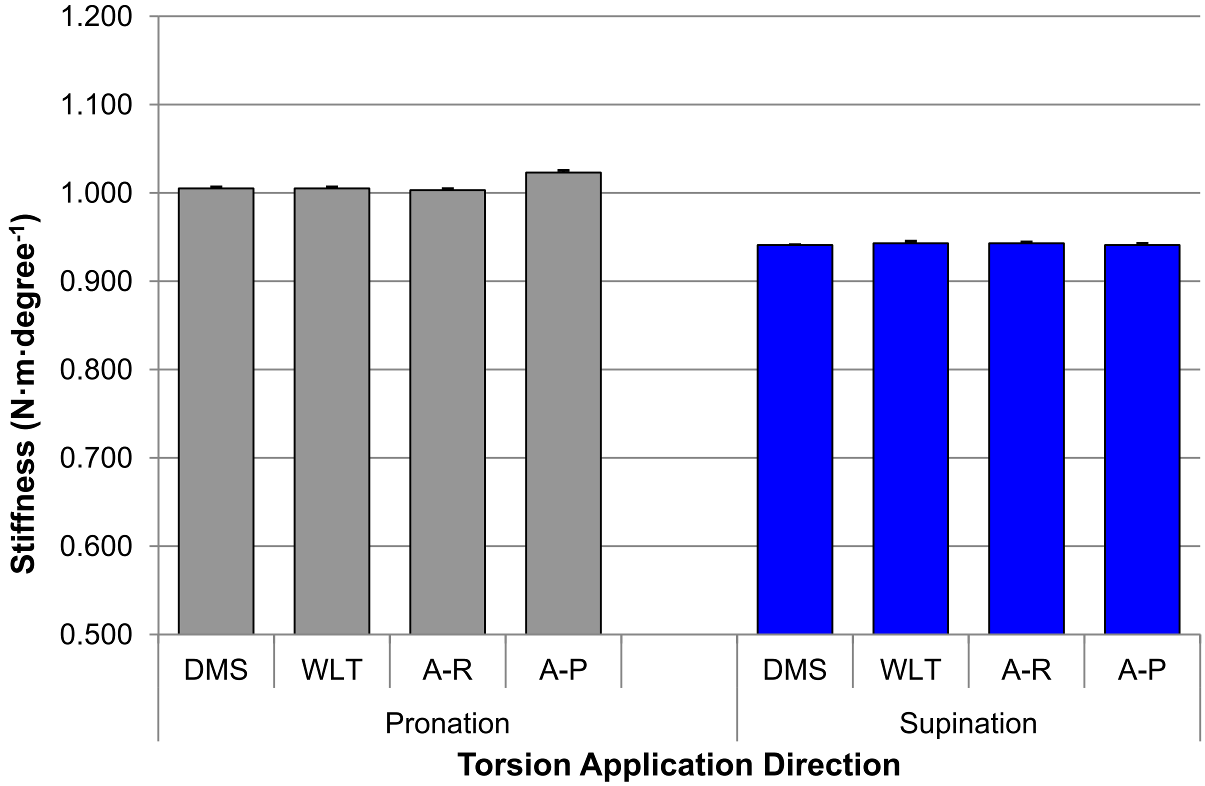

Figure A-6. Mean (*SEM*) stiffness values for pronation and supination obtained for each sole construction type on the flexibility test.

Discussion

The average thickness of the forefoot and rearfoot of the boots differed among the sole construction types. For example, there was as much as a 5.03-mm difference between the DMS and the A-R boots in the forefoot area. In the rearfoot, the greatest difference in thickness was 7.32 mm between the DMS and the A-R constructions. However, these differences explained only some of the impact value differences.

There was a meaningful difference in impact values (i.e., ES >1.0) among the four sole constructions in the forefoot area (Table A-1). In the rearfoot area, there was also a meaningful difference among all footwear types (i.e., ES > 1.0). If evaluated only on the impact characteristic of peak acceleration, the best of these footwear types would be the WLT construction. This boot also had the longest time to peak acceleration, which confirms that this boot has the best shock attenuation characteristics.

For forefoot flexibility, a lower stiffness value is usually desirable in a boot because it implies a lower resistance to flexion across the metatarsal heads. In this case, the DMS was meaningfully better than the other footwear types (ES > 1.0). However, the WLT was also meaningfully better (ES > 1.0) than the A-R and the A-P boots in forefoot flexion.

In midfoot torsion, there was only one meaningful difference among the footwear types. The DMS, the WLT, and the A-R were not meaningfully different (ES < 0.2) in pronation. The only boot that was different was the A-P. This boot exhibited the greatest resistance to rotation in pronation. There were no differences in the boots in the resistance to rotation in the supination direction (ES < 0.2).

Overall, in assessing the different footwear types using the mechanical tests, it would appear that the DMS exhibited the most desirable qualities in a sole construction. However, it should be noted that this does not imply that it is the best boot from a functional point of view.

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APPENDIX B

Size Tariffs of Test Boots

Table B-1
Sizes Tariffs of Test Boots

Size		Sole Construction Type[a] DMS (pr.)	WLT (pr.)	A-R (pr.)	A-P (pr.)	Size		Sole Construction Type[a] DMS (pr.)	WLT (pr.)	A-R (pr.)	A-P (pr.)
4	R	6	6	6	6	9	R	36	36	36	36
	W	6	6	6	6		W	48	48	48	48
	XW	12	12	12	12		XW	12	12	12	12
4½	R	6	6	6	6	9½	R	48	48	48	48
	W	12	12	12	12		W	48	48	48	48
	XW	6	6	6	6		XW	12	12	12	12
5	R	6	6	6	6	10	R	48	48	48	48
	W	12	12	12	12		W	42	42	42	42
	XW	12	12	12	12		XW	12	12	12	12
5½	R	6	6	6	6	10½	R	42	42	42	42
	W	12	12	12	12		W	36	36	36	36
	XW	6	6	6	6		XW	12	12	12	12
6	R	12	12	12	12	11	R	30	30	30	30
	W	18	18	18	18		W	24	24	24	24
	XW	6	6	6	6		XW	6	6	6	6
6½	R	12	12	12	12	11½	R	24	24	24	24
	W	18	18	18	18		W	24	24	24	24
	XW	6	6	6	6		XW	6	6	6	6
7	R	12	12	12	12	12	R	18	18	18	18
	W	18	18	18	18		W	12	12	12	12
	XW	12	12	12	12						
7½	R	18	18	18	18	12½	R	12	12	12	12
	W	24	24	24	24		W	6	6	6	6
	XW	12	12	12	12						
8	R	24	24	24	24	13	R	6	6	6	6
	W	30	30	30	30		W	6	6	6	6
	XW	12	12	12	12						
8½	R	30	30	30	30		*N*	990	990	990	990
	W	42	42	42	42						
	XW	12	12	12	12						

Note. Shaded cells indicate that all boots on hand in that size and sole construction were issued.

APPENDIX C

Questionnaire Administered at Test Initiation

(Reprint of original)

For Office Use Only				
Boot Type: DAR	WLT	DMS	DAP	
Checked: ________________				
Date: ___________________				
Entered: _________________				

COMBAT BOOT TEST

CLOTHING INITIAL ISSUE

Privacy Act Statement

Purpose(s):
To evaluate military footwear under consideration by the Army; to determine acceptability of footwear items in consideration of procurement. To locate individuals who participate in a user assessment or evaluation of footwear during basic combat training.

Routine uses of records maintained in the system, including categories of users and the purposes of such uses:
In addition to those disclosures generally permitted under 5 U.S.C. 552a(b) of the Privacy Act. These records or information contained therein will not be disclosed outside the DoD. Reports published on findings do not contain any personal information, but list demographics in the aggregate. The `Blanket Routine Uses' set forth at the beginning of the Army's compilation of systems of records notices apply to this system.

1. Last Name: _______________________ First Name: _____________________ MI: ____
2. Last four digits of your Social Security Number: __________

GO TO THE NEXT PAGE AND CONTINUE ANSWERING THE QUESTIONS.

Use a pen or pencil to complete this questionnaire. When filling in a circle, please fill it in completely – like this: ● and NOT like this: ⊗

3. What is your status? Fill in **ONE** answer.

O National Guard

O Enlisted Reserve

O Regular Army

4. What is your gender?

	Male	**Female**
	O	O

5. What is your date of birth? Month: ______ Year: ______

6. What date did you arrive at the 120th (Reception)? __________ (Month) __________ (Day) __________ (Year)

7. How tall are you in bare feet? _______ feet, _______ inches

8. How much do you weigh without clothes on? _______ pounds

9. Which group below most closely describes your ethnic or racial group? Fill in **ONE** answer.

O White, non-Hispanic

O Black, non-Hispanic

O Hispanic

O American Indian/Alaskan Native

O Oriental/Asian

O Pacific Islander

O Other (Specify your ethnic/racial group(s). ________________________________)

10. Enter the **BRAND** and **STYLE** of running shoes you are wearing at the 120th (Reception).

Brand: ___________________________ Style: ___________________________

11. Enter the **SIZE** of the running shoes you are wearing. Be sure to include **LENGTH** and **WIDTH.**

Length: ___________________________ Width: ___________________________

	YES	**NO**
12. Did you get your running shoes since you have been at the 120th (Reception)?	O	O

13. What type of shoes have you worn **MOST OFTEN during the last 12 months**? Fill in **ONE** answer.

O Low-heel leather

O Low-top sneakers or running shoes

O High-top sneakers or running shoes

O Low-heel boot

O Low-heel sandals

O High-heel dress

O Other (Describe the shoes you wore: ________________________________)

14. What is the highest level of education that you have completed? Fill in **ONE** answer.

O Some high school

O High school graduate/GED

O 1 to 3 years of college

O College graduate

O Some graduate school or higher

15. What jobs have you had **during the last 6 months**? If you were in school, list "Student" as a job. Also list jobs that you had in the last 6 months in addition to going to school.

____

16. Which statement below best describes your smoking habits and your use of smokeless tobacco (chewing, dipping, or pinching) **during the 12 months** before you arrived at Fort Jackson? Fill in **ONE** answer for each.

Smoking	**Smokeless Tobacco**
O I have never been a smoker	O I have never used smokeless tobacco
O I smoked but quit more than a year ago	O I used it but quit more than a year ago
O I smoked but quit during the past year	O I used it but quit during the past year
O I smoke 1 to 10 cigarettes per day	O I use it 1 to 2 times per day
O I smoke 11 to 20 cigarettes per day	O I use it 3 to 5 times per day
O I smoke more than a pack a day	O I use it more than 5 times per day

		YES	NO
17.	Have you ever had an accident or injury that required surgery to repair the damage?	O	O

If YES, what year did the injury occur and what surgery was required?

Year: ______ Surgery:____

18. Have you ever injured or had an accident to one or more parts of the body listed below that caused you to change your daily activities or miss school or work for several days? **If you fill in YES for a part of the body, enter the name of the most recent injury and the year the injury occurred**.

YES	NO	Body Part	Injury Name	Year of Injury
O	O	Upper Back	____________________	__________
O	O	Lower Back	____________________	__________
O	O	Hip	____________________	__________
O	O	Upper Leg	____________________	__________
O	O	Knee	____________________	__________
O	O	Lower Leg	____________________	__________
O	O	Ankle	____________________	__________
O	O	Foot	____________________	__________
O	O	Toes	____________________	__________

19. Have you ever gone to a doctor or sought other medical help for the injuries to your feet, knees, or legs listed below? I**f you fill in YES for an injury, enter the part of your body that was injured and the year the injury occurred.**

YES	NO	Injury	Part Injured	Year of Injury
O	O	Broken Bone	____________________	__________
O	O	Stress Fracture	____________________	__________
O	O	Torn Cartilage	____________________	__________
O	O	Knee Injury	____________________	__________
O	O	Sprained Ankle	____________________	__________
O	O	Other Sprain	____________________	__________
O	O	Tendinitis	____________________	__________
O	O	Ruptured Tendon	____________________	__________

20. In regard to **physical activity**, how would you describe your life before coming into the Army? Fill in **ONE** answer.

Very Inactive	Somewhat Inactive	Average	Somewhat Active	Very Active
O	O	O	O	O

21. How would you rate yourself in terms of **physical ability and fitness** compared with other people of your same sex and age? Fill in **ONE** answer.

Much Below Average	Somewhat Below Average	Average	Somewhat Above Average	Much Above Average
O	O	O	O	O

	YES	**NO**
22. Were you on any varsity sports teams in school or in college?	O	O

IF YOU ANSWERED NO, GO TO QUESTION 23.

22a. What varsity sports teams were you on? ____

22b. What years were you on a varsity sports team? Fill in all that apply.

O 2009 O 2008 O 2007 or earlier

23. Have you participated in any non-varsity, organized sports, like school intramural teams, YMCA or church teams, American Legion teams?

YES	**NO**
O	O

IF YOU ANSWERED NO, GO TO QUESTION 24.

23a. What non-varsity, organized sports teams were you on? _________________________________

23b. What years were you on a non-varsity, organized sports team? Fill in all that apply.

O 2009 O 2008 O 2007 or earlier

24. **Over the last two months**, how often did you exercise or play sports for more than 30 minutes at a time? Fill in **ONE** answer.

O No exercise or sports in the last two months

O Less than once per week

O One time per week

O Two or three times per week

O Four or more times per week

25. How did your exercise or sports participation in the last two months compare to your usual level during the last year? Fill in **ONE** answer.

O Did much more exercise in the last two months

O Did somewhat more exercise in the last two months

O Did about the same amount of exercise in the last two months

O Did somewhat less exercise in the last two months

O Did much less exercise in the last two months

26. **In the last two months**, how many days per week did you usually run or jog? Fill in **ONE** answer.

None	1-2 days per week	3-4 days per week	5-6 days per week	7 days per week
O	O	O	O	O

27. **In the last two months**, how many days per week did you usually do weight training (free weights, universals, nautilus, etc.)? Fill in **ONE** answer.

None	1-2 days per week	3-4 days per week	5-6 days per week	7 days per week
O	O	O	O	O

	YES	**NO**
28. Were you given any **medical waivers** to enter the Army?	O	O

If YES, describe the medical waivers:____

MEN: TURN IN YOUR QUESTIONNAIRE. Thank you for your time and help.

WOMEN: PLEASE ANSWER THE QUESTIONS ON THE NEXT PAGE.

FOR WOMEN ONLY

29. How old were you when you had your first menstrual period? ____________________
(Age in years)

	YES	NO
30. Have you ever been pregnant?	O	O

***IF YOU ANSWERED NO, GO TO QUESTION 31*.**

30a. What was the month and year that your last pregnancy ended? __________ __________
(Month) (Year)

31. **During the last 12 months**, has the number of days between your periods changed?

YES	NO
O	O

***IF YOU ANSWERED NO, GO TO QUESTION 32*.**

31a. How have your periods changed in the last 12 months? Fill in **ONE** answer.

O Longer

O Shorter

O Irregular

O Stopped

32. **During the last 12 months**, have you taken birth control pills or any other hormonal therapy?

YES	NO
O	O

TURN IN YOUR QUESTIONNAIRE. Thank you for your time and help.

GOOD LUCK IN THE ARMY.

APPENDIX D

Questionnaire Administered at the End of the Training Cycle

(Reprint of original)

For Office Use Only

Boot Type: DAR WLT DMS DAP

Checked: _______________

Date: ___________________

Entered: ________________

COMBAT BOOT TEST

TRAINING CYCLE

Privacy Act Statement

Purpose(s):
To evaluate military footwear under consideration by the Army; to determine acceptability of footwear items in consideration of procurement. To locate individuals who participate in a user assessment or evaluation of footwear during basic combat training.

Routine uses of records maintained in the system, including categories of users and the purposes of such uses:
In addition to those disclosures generally permitted under 5 U.S.C. 552a(b) of the Privacy Act. These records or information contained therein will not be disclosed outside the DoD. Reports published on findings do not contain any personal information, but list demographics in the aggregate. The `Blanket Routine Uses' set forth at the beginning of the Army's compilation of systems of records notices apply to this system.

1. Last Name: ______________________ First Name: ____________________ MI: ____
2. Last four digits of your Social Security Number: __________
3. Company and Battalion to which you are presently assigned: ____________________________

GO TO THE NEXT PAGE AND CONTINUE ANSWERING THE QUESTIONS.

Use a pen or pencil to complete this questionnaire. When filling in a circle, please fill it in completely – like this: ● and NOT like this: ⊗

4. During your basic training, have you ever worn running shoes instead of boots **BECAUSE OF FOOT, ANKLE, KNEE, OR LEG PROBLEMS**?

YES	**NO**
O	O

5. Do you still have the hot weather boots that you received during in-processing clothing issue while you were at the 120th (Reception) before you began basic training?

YES	**NO**
O	O

IF YOU ANSWERED YES, GO TO QUESTION 6.

5a. Why did you exchange the hot weather boots that you received during in-processing clothing issue?

____

____

6. Your hot weather boots came with insoles in them. Have you taken the insoles out of any of your hot weather boots?

YES	**NO**
O	O

IF YOU ANSWERED NO, GO TO QUESTION 7.

6a. Why did you take the insoles out of your hot weather boots?

____

____

7. Have you put any insoles in the hot weather boots, other than those that came with the boots?

YES	**NO**
O	O

8. How many pairs of socks do you usually wear with your hot weather boots? Fill in **ONE** answer.

O One pair of socks

O Two pairs of socks

9. Since you started basic training, have you worn any socks that **WERE NOT** issued to you during in-processing clothing issue while you were at the 120th (Reception)?

YES	NO
O	O

10. Since you started basic training, have you gone on sick call because of **FOOT, ANKLE, KNEE, OR LEG PROBLEMS**?

YES	NO
O	O

IF YOU ANSWERED NO, GO TO QUESTION 11.

10a. About how many times have you gone on sick call **BECAUSE OF FOOT, ANKLE, KNEE, OR LEG PROBLEMS**?

__________ times

10b. What problem, or problems, have you had with your feet, ankles, knees, or legs?

____

____

	YES	NO
10c. Were you put on profile for these foot, ankle, knee, or leg problems?	O	O

	YES	NO
11. Have the soles of your hot weather boots ever seemed to be slippery?	O	O

IF YOU ANSWERED NO, GO TO QUESTION 12.

11a. What sorts of surfaces were you on when the soles of your hot weather boots seemed to be slippery?

____

	YES	NO
12. Do your feet sweat too much when you are wearing your hot weather boots?	O	O

IF YOU ANSWERED NO, GO TO QUESTION 13.

12a. What do you think causes the sweating? **Fill in ALL that apply**.

O the BOOTS

O the SOCKS

O the TEMPERATURE

O Other things. Please explain: ____

13. As you walk over stones and rocks in your hot weather boots, do you feel the stones and rocks through the soles?

YES	**NO**
O	O

14. Do stones, dirt, or mud build up in the tread of the heels or soles of your hot weather boots?

YES	**NO**
O	O

	YES	**NO**
15. Do your hot weather boots fit you properly?	O	O

16. Do your hot weather boots provide **ADEQUATE SUPPORT TO YOUR ANKLES**?

YES	**NO**
O	O

17. Do your hot weather boots provide **ADEQUATE SUPPORT IN THE ARCH AREA OF YOUR FEET**?

YES	**NO**
O	O

18. Is there **ENOUGH ROOM FOR YOUR TOES IN THE TOE AREA OF YOUR HOT WEATHER BOOTS?**

YES	**NO**
O	O

	YES	**NO**
19. Do the insides of your hot weather boots press or rub against your skin?	O	O

IF YOU ANSWERED NO, GO TO QUESTION 20.

19a. Where do the hot weather boots press or rub against your skin?

____

____

20. Rate your hot weather boots with regard to overall comfort. **Fill in ONLY ONE answer**.

Very Comfortable	Somewhat Comfortable	Adequate	Somewhat Uncomfortable	Very Uncomfortable
O	O	O	O	O

21. Since receiving your **COLD WEATHER BOOTS** (the boots with the black lining inside) during deferred clothing issue (Class A clothing issue), which boots have you worn more often? **Fill in ONE.**

O Hot weather boots

O Cold weather boots

22. Which boots do you prefer? **Fill in ONE.**

O Hot weather boots

O Cold weather boots

22a. Explain the reasons you prefer those boots.

____

____

23. Compare the amount of **PHYSICAL ACTIVITY** you have been doing during basic training with the amount you did before coming into the Army. **Fill in ONLY ONE answer**.

O I am much more active now

O I am somewhat more active now

O I do about the same amount of physical activity now as before

O I am somewhat less active now

O I am much less active now

24. How would you rate yourself in terms of **PHYSICAL ABILITY AND FITNESS** compared with other people of your same sex in your platoon and company. **Fill in ONLY ONE answer**.

O My physical ability and fitness is much below average

O My physical ability and fitness is somewhat below average

O My physical ability and fitness is average

O My physical ability and fitness is somewhat above average

O My physical ability and fitness is much above average

25. Since coming to Fort Jackson, have you ever been hospitalized or been in the infirmary?

YES	**NO**
O	O

	YES	**NO**
26. Have you spent any time in the PT rehab platoon (PTRP)?	O	O

	YES	**NO**
27. Have you spent any time in the Fitness Training Unit (FTU)?	O	O

28. Please write any comments you may have about your experiences with your hot weather boots during training.

____

____

TURN IN YOUR QUESTIONNAIRE. Thank you for your time and help.